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THE MARINE CORPS FLYING HOUR PROGRAM AT MARFORLANT

by

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December 1998

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THE MARINE CORPS FLYING HOUR PROGRAM AT MARFORLANT

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ABSTRACT

The goal of this thesis is to determine the best way to manage the Flying Hour Program (FHP) from the perspective of the U.S. Marine Forces Atlantic (MARFORLANT) Aviation Budget Officer. The thesis has two main objectives. The first objective is to describe the organization and current financial management issues related to the FHP at the Department of the Navy (DON) and MARFORLANT levels. An historical overview of the FHP, an analysis of federal and defense budgeting dynamics, and an impact analysis of the Marine Aviation Campaign Plan are provided. The second objective is to conduct quantitative analysis of selected MARFORLANT data to better understand FHP cost behavior. Regression results are compared with previous DON research to determine the suitability of Cost Per Hour as the most reliable FHP metric. Analysis confirmed that there is a direct relationship between fuel and flight hours, but showed virtually no correlation between flight hours and aviation maintenance costs. These findings indicate that regression models show too much variability for them to be used to displace the DON OP-20 model as the primary means for budget forecasting for the FHP. The thesis concludes that the Aviation Budget Officer must continue to rely on qualitative budgeting skills to maximize the financial condition of MARFORLANT Aviation.

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LIST OF ACRONYMS

AIRLANT	Naval Air Forces, Atlantic Fleet
AIRPAC	Naval Air Forces, Pacific Fleet
AFO	Aircraft Flight Operations
AMF	Aircrew Manning Factor
AMSR	Aviation Maintenance Supply Readiness Working Group
AOM	Aircraft Operations Maintenance
AVDLR	Aviation Depot Level Repairables
BCM	Beyond the Capability of Maintenance
BES	Budget Estimate Submission
CAT	Pilot Training Category
CER	Complete Engine Repair
CPH	Cost Per Hour
CSR	Crew Seat Ratio
DBOF	Defense Business Operations Fund
DLR	Depot Level Repairables or Aviation Depot Level Repairables
DOD	The Department of Defense
FHP	The Department of the Navy Flying Hour Program
FHPS	Flying Hour Program Projection System
FMF	Fleet Marine Force
FY	Fiscal Year
FYDP	Future Years Defense Program
GAO	Government Accounting Office
H/M/C	Hours flown per Month per Crew
IMA	Intermediate Maintenance Activity
JTF	Joint Task Force
MACP	Marine Aviation Campaign Plan
MAG	Marine Aircraft Group
MAGTF	Marine Air Ground Task Force
MALS	Marine Aviation Logistics Squadron
MARFORLANT	U. S. Marine Forces Atlantic
MARFORPAC	U. S. Marine Forces Pacific
MEF	Marine Expeditionary Force

MEU	Marine Expeditionary Unit
MNT	Aviation Fleet Maintenance
MTBF	Mean Time Between Failures
NAVAIR	Director, Naval Air Warfare
NAVICP	Director, Naval Inventory Control Point
NATOPS	Naval Air Training and Operating Procedures Standardization
NAVCOMPT	Office of the Assistant Secretary of the Navy, Office of Budget
NAVSUP	Naval Supply Systems Command
NCCA	Naval Center For Cost Analysis
OFC	Operating Target Functional Category
OMA	Organizational Maintenance Activity
OMFTS	Operational maneuver From the Sea
OMB	Office of Management and Budget
O&M, N	Navy Operations and Maintenance Appropriation
OPTAR	Operating Target
PAA	Primary Aircraft Authorized
PMR	Primary Mission Readiness
POM	Program Objectives Memorandum
PPBS	Planning, Programming, and Budgeting System
TACAIR	Tactical and Anti-Submarine Warfare Aviation
TAD	Temporary Additional Duty
T/M/S	Aircraft Type Model Series
TOT	Transportation of Things
T&R Manual	Training and Readiness Manual
USACOM	United States Atlantic Command
UTIL	Monthly Aircraft Utilization Rate
WCF	Working Capital Funds
2^{nd} MAW	Second Marine Aircraft Wing

I. INTRODUCTION

> As critical as Marine Aviation is to "Operational Maneuver From the Sea" (OMFTS), we need to ensure that when it comes time to fight, our aircraft, our aviators, and those who support them are in the highest possible state of readiness. [Ref. 1]

General Charles Krulak's direction summarizes the endstate he expects for Marine Aviation. This thesis describes the key financial management dynamics and challenges of accomplishing that endstate. In particular, it examines the Flying Hour Program (FHP) at U.S. Marine Forces Atlantic (MARFORLANT) from the perspective of MARFORLANT's Aviation Budget Officer. This officer's principal duty is to understand how to effectively manage "blue dollars" from the Flying Hour Program, which allocates the majority of financial resources for Marine Aviation readiness.

A. AVIATION AND THE DEFENSE BUDGET

Most individuals associated with the Department of Defense are fully aware of the budget struggles of the post cold war era. Each service annually faces difficult decisions about the allocation of limited resources. For the United States Marine Corps and Marine Aviation, this is not an unfamiliar problem. Consider the description of the Marine Corps' health from a similar budget cutting era 50 years ago:

> Cates (General Clifton B. Cates) Corps shrank to fit federal budgets rather than expanding to fit contingency plans. Whereas Headquarters thought it needed at least 114,200 Marines to meet its peacetime duties, its funded manpower fell from 92,222 to 83,609 men in 1948 and dropped again to 74,279 by the spring of 1950. About 50,000 men were assigned to the operating forces, but the FMF had only about 35,000 men in the two divisions and aircraft wings, while nearly 15,000 men served in shore security detachments and ships guards. The Corps supporting establishment was so small and its tasks for maintaining Corps bases so extensive that many FMF troops spent more time housekeeping than training. ...It (the diminished budget) was not enough to buy adequate manpower, training, or new equipment; the Marines lived on skeletonized units, World War II surplus, and dwindling amounts of Navy amphibious shipping of World War II vintage. [Ref. 2]

Although actual numbers are different, today's potential problems and trends are the same. Decisions about budget resources involve issues about purchasing or maintaining equipment, manning units, cutting or funding major programs, or even about the very existence of military services. For the Marine Corps, this is the context that should be remembered when considering the specific research question of aviation budget management.

Ultimately, discussions about budgets and Marine Aviation are not just about the readiness of the aircraft and pilots to execute their missions. Budget discussions carry the implications of whether the Marine Corps can truly execute its mission. Whether the discussion involves using helicopters or tilt rotor aircraft for aerial envelopments, or is concerned about close air support in conjunction with an attack by a ground combat element, aviation is essential to the Marine Corps' existence. As Marine leaders so often state, without the A in aviation there is no MAGTF (Marine Air Ground Task Force), and the Marine Corps becomes just another light infantry unit.

To keep Marine aircraft units adequately funded, the Marine Corps depends upon the effective administration of appropriations through the Department of the Navy's Flying Hour Program. The Flying Hour Program is the Navy and Marine Corps' principle programming and budgeting mechanism for financing the operational and logistical readiness of aviation squadrons. Like the state of Marine Corps resources 50 years ago, today's Marine Corps leaders and staff still fight to keep Marine Aviation fully funded because of three general factors: the continuous reduction of available federal funds, the post-Cold War drawdown, and an increasing operational tempo. In its attempts to prevent [Marine and] Naval Aviation from becoming a "skeleton force," the Department of the Navy has attempted to improve its understanding of the cost dynamics inherent in budgeting by flight hours. However, the Marine Corps has taken an additional step by trying to reduce their operational tempo and improve their logistical health through a management strategy called the Marine Aviation Campaign Plan (MACP). First published in 1996, the Marine Aviation Campaign Plan is a comprehensive program to better balance all aviation goals within the constraints of existing resources.

B. OBJECTIVES AND RESEARCH QUESTIONS

With today's aviation challenges in mind, this thesis examines and analyzes the dynamics of funding Marine Aviation at U.S. Marine Forces Atlantic. Research is oriented towards outlining and understanding the financial management tasks and

obstacles faced by the MARFORLANT Aviation Budget Officer, who is the command's primary manager of the Flying Hour Program.

Since MARFORLANT is an operational command primarily responsible for Marine Aviation units that train and deploy from the east coast of the United States, the Aviation Budget Officer's key task is to ensure that Flying Hour Program dollars are properly allocated to subordinate units. Therefore, the primary research question of this thesis is: **How should the Marine Corps Flying Hour Program at Marine Forces Atlantic be managed in order to maximize its value to MARFORLANT Aviation?**

To answer that question, research efforts are broken down into two objectives. The first objective is to gain an understanding of the Flying Hour Program as viewed by both the Department of the Navy and MARFORLANT. This includes a historical overview of the Flying Hour Program at the Department of the Navy level, the impact of MARFORLANT organization on the Flying Hour Program, an overview of the Marine Aviation Campaign Plan, and a survey of financial management levers of control available to the MARFORLANT Aviation Budget Officer. The second objective is to conduct deductive cost analysis similar to work performed in previous research, and analysis of the FHP at MARFORLANT as a management control system. A comparison of findings between MARFORLANT and previous research at other levels can help indicate whether the conclusions about FHP cost behavior and FHP management from previous research can be applied at MARFORLANT.

To summarize the primary and secondary research questions are:

Primary Question:

1. How should the Marine Corps Flying Hour Program at Marine Forces Atlantic be managed in order to maximize its value to MARFORLANT Aviation?

Secondary Questions:

1. What are the historical trends of flying hour program budgeting and execution at MARFORLANT?

2. How has the switch from flying hour based budgeting to event based budgeting affected Marine aviation at MARFORLANT?

3. What are the budgeting dynamics that currently threaten full funding of MARFORLANT's aviation programs?

4. What is the financial condition of the MARFORLANT aviation program compared with MARFORPAC, and if there is a difference, what explains the differences?

5. Can new financial models be developed to more accurately capture the realities of MARFORLANT aviation?

6. Can simulation be used to test the accuracy of current and alternative aviation cost models at MARFORLANT?

7. What future budgeting and operating adjustments does MARFORLANT need to make in order to successfully meet the goals of the Marine Aviation Campaign Plan?

C. SCOPE

Several Naval Postgraduate School Theses about the Flying Hour Program have been written over the past 13 years. However, most analyzed the Flying Hour Program from a macro level such as the Department of the Navy or from the perspective of a major claimant such as Commander, Naval Air Forces Pacific. This research narrows its focus specifically to MARFORLANT and its subordinates units, except where an examination of factors from a higher echelon is essential to the research. Therefore the analysis and conclusions focus not on reinventing the Flying Hour Program, but on understanding the FHP's current condition. In addition, the majority of the analysis is focused on the TACAIR component of the FHP, because the majority of appropriated funds go to pay for TACAIR costs.

D. METHODOLOGY

Two approaches will be used to study these problems. Archival research briefly develops the background of the Flying Hour Program at the Department of the Navy level, then focuses on the dynamics of Marine Aviation and the FHP at MARFORLANT. Secondly, both quantitative and qualitative analyses examine MARFORLANT cost behavior and budgeting actions. Regression analysis is the primary quantitative method used. Qualitative analysis uses Robert Simons' framework on management control systems [Ref. 3] as a framework to discuss the FHP budgeting process and the Marine Aviation Campaign Plan. The analysis of cost behavior is deductively compared to research hypotheses developed from previous research. Cost data is analyzed to see whether the assumptions inherent in the Flying Hour Program are actually reflected in cost behavior at 2nd Marine Aircraft Wing and subordinate Marine Aircraft Groups.

Analytical conclusions about MARFORLANT FHP cost behavior and the budgeting dynamics of the FHP are used to answer the primary and secondary research questions.

E. THESIS ORGANIZATION

This thesis is divided into six chapters.

Chapter I is the introduction and gives a large scale background about the importance of studying Marine Aviation and the Flying Hour Program. It states research objectives, research questions, the scope of the research, and its overall methodology.

Chapter II outlines background essential towards understanding the conceptual framework of the thesis. Included in this is a brief background description of Federal budgeting and PPBS dynamics, a description of the OP-20 model, the search for alternative parametric costing models, and an introduction to Simon's theory on management control systems.

Chapter III provides background beginning with the Marine Corps' interaction with the Flying Hour Program, the importance of Marine Aviation to the MAGTF concept, and problems facing Marine Aviation in the 90's. In addition, it surveys the organization of MARFORLANT for aviation and how MARFORLANT plugs into the Flying Hour Program and the Planning, Programming and Budgeting System. (PPBS)

Chapter IV establishes the techniques used for both quantitative and qualitative research in the thesis and then presents the collected cost data. First, parametric analysis using regression techniques is discussed. Secondly, qualitative analysis using the conceptual framework of Simons is explained. The method used to adjust cost data is discussed. Finally, cost data is presented. This data includes monthly obligation costs from 2nd Marine Aircraft Wing, and annual MARFORLANT costs extracted from Commander Naval Air Force, Atlantic cost reports.

Chapter V is the analysis of cost data, and a discussion of budgeting dynamics within the framework of Simons', <u>Levers of Control</u>. The results of regression analysis are presented and interpreted. In addition, other relevant comparisons of cost data are presented. Qualitative analysis primarily discusses the impact of Department of the Navy budgeting, the FHP, and the Marine Aviation Campaign Plan on MARFORLANT Aviation.

Finally, Chapter VI summarizes the answers to the primary and secondary research questions, and offers suggestions for future research.

II. THEORETICAL FRAMEWORK, DEFENSE BUDGETING, THE OP-20, AND LITERATURE REVIEW

This chapter addresses background material essential to understanding the theoretical framework of the rest of the thesis. It begins with a brief summary of relevant facts about federal budgeting and DOD's Planning, Programming and Budgeting System. Next, the chapter describes the basic Flying Hour Program model for predicting flight hours and cost. Finally, important previous research relevant to the thesis is summarized.

A. THEORETICAL FRAMEWORK

The Department of the Navy has used the flight hour as a common metric to budget for aviation programs for nearly 30 years. Using the flight hour as a common metric means that nearly all FHP cost requirements are stated in a "Cost Per Hour" (CPH) format. (E.g., COST/HOURS FLOWN = COST PER HOUR). The simplicity of this relationship immediately leads to misperceptions and assumptions that can cause problems in understanding the Flying Hour Program. Two common misperceptions about Cost-Flight Hour are listed below.

1. Flight hours statistically correlate closely to cost. Therefore, an accurate prediction of total flight hours should yield an accurate prediction of total cost. Flight costs vary directly with the number of hours flown.

2. Flying Hour Program budgets can be easily adjusted simply by multiplying the current cost per hour by the number of flight hours to determine the amount of dollars that should be added or subtracted from unit budgets.

These misperceptions have lead to three prevailing problems with the Flying Hour Program and the OP-20 as a predictive financial model:

1. The Flying Hour Program frequently does not accurately forecast program costs.

2. The Flying Hour Program frequently does not regularly meet its budgeted flight hour goals.

3. The Flying Hour Program has been unable to demonstrate statistically that flying a predetermined percentage of required flight hours correlates to a pre-determined level of readiness.

Previous research and investigative reports over the past 30 years have repeatedly identified these problems. In addition, several attempts have been made to build a better predictive model by either determining a linear relationship between cost and flight hours or by searching for other metrics that might correlate to Naval Aviation costs.

Since this thesis examines the Flying Hour Program at MARFORLANT from both a quantitative and qualitative perspective, this chapter reviews the basic structure of the OP-20, the basic mathematical model the Flying Hour Program uses for aviation budgeting. The term OP-20 refers to the name of the budget exhibit that annually displays cost and flight hour budget predictions for the Flying Hour Program. Understanding the structure of the predictive models in the OP-20 is essential to comprehending the budgeting dynamics analyzed in this and previous Flying Hour Program research efforts. With a clear understanding of the OP-20, key conclusions from previous research efforts may be used as deductive benchmarks for data analysis, and for developing conclusions about the Flying Hour Program at MARFORLANT.

B. FEDERAL GOVERNMENT DYNAMICS AFFECTING THE FHP

A brief analysis of the environment in which defense budgets are formulated provides insight into the processes and problems of the Flying Hour Program. This is essential because the sheer size and problems of the federal budget dwarf any single part of the Defense Department program such as the FHP. An analysis without a perspective on the workings of Congress, the federal budget and PPBS will yield useless conclusions, i.e., that the government should simply "invest more money" in the Flying Hour Program to fix its problems.

Despite the budget cuts, tax increases, and revenue increases that led to the FY98 federal budget surplus of 71 billion dollars [Ref. 4], the federal government had 29 straight years of budget deficits (FY1968-FY1997), that have accumulated into a public debt of over 5.5 Trillion dollars. [Ref. 5] Even more sobering is the admission by the Congressional Budget Office that "At this point, there is little firm information about the sources of income that produced the added revenues in 1998 and their implications for the revenue growth in future years." [Ref. 6] Although these trends have made budget forecasts for the next 10 years positive, the nation faces the chance that conditions may adversely change in future years. As the Congressional Budget Office noted, "the budget

outlook can improve or deteriorate rapidly, in part because changes in the fiscal position of the government tend to feed on themselves, producing larger changes in the same direction…a reversal of those changes could initiate a vicious cycle—with increasing debt and increasing interest costs—that could eliminate the projected surpluses." [Ref. 7] Additionally, without the help of revenues from Social Security and the U.S. Postal Service, the federal budget still had a deficit of 28 billion dollars in FY98. [Ref. 8] So, despite the "peace dividend" of the 1990s and the strong economy, Congress is not in a position to appropriate new spending to plus up many Department of Defense programs.

The Department of Defense also faces common misperceptions about the source of budget deficits and the resulting public debt. The defense budget requested by the President for FY 1999 is about 40 percent below its 1985 peak. [Ref. 9] Yet, since it is still the largest discretionary spending program, it remains political prey for members of Congress searching for budget cuts. Despite the fact that in 1998 mandatory spending and the cost of interest on the debt was 66 percent of Federal spending, the political unpopularity of entitlement cuts makes it easy for legislators to give in to the common public misperception that defense spending causes the public debt. [Ref. 10] Figure 2.1 documents that regardless of the measure used, the defense budget is the smallest it has been in real dollars in 40 years.

In Fiscal Year 1998, the sum of Department of the Navy Operations and Maintenance appropriations for the Flying Hour Program was 3.2 billion dollars for both active and reserve forces. [Ref. 11] This is 1.2 percent of the DOD budget and 3.8 percent of the Department of the Navy budget. [Ref. 12] Citing these figures is not intended to trivialize the hundreds of millions of dollars administered through the Flying Hour Program. Nevertheless, they emphasize that the Flying Hour Program competes with other programs on Capitol Hill and in the Pentagon for limited funding annually in highly complex and political budget battles.

C. THE FLYING HOUR PROGRAM AND PPBS

The annual budget battle for limited resources begins long before a President's Budget is submitted to Congress. The decisions that determine which programs are funded and how much they receive comes through repetitive cycles of the Planning, Programming and Budgeting System (PPBS). Very broadly, PPBS is the Department of Defense system that allocates financial resources to meet perceived military threats to national security in both immediate and future budget years. In other words, the

complexity of budgeting for the Flying Hour Program is not limited simply to the next budget year, but also includes the following five budget years at a minimum.

In the Planning phase, an iterative process occurs when the national security council, the Joint Staff, the Service Chiefs and the Commanders in Chief (CinC) of the

Spending	% of Federal Outlays		% of Net Public Spending	% of GDP
Fiscal Year	DOD	Non-DOD	DOD	DOD
1950	27.4	72.6	18.5	4.3
1955	51.4	48.6	35.5	8.9
1960	45.0	55.0	30.3	8.0
1965	38.8	61.2	25.2	6.7
1970	39.4	60.6	25.4	7.6
1971	35.4	64.6	22.4	6.9
1972	32.5	67.5	20.6	6.4
1973	29.8	70.2	19.0	5.6
1974	28.8	71.2	18.2	5.4
1975	25.5	74.5	16.5	5.5
1976	23.6	76.4	15.4	5.1
1977	23.4	76.6	15.5	4.8
1978	22.5	77.5	15.2	4.7
1979	22.8	77.2	15.4	4.6
1980	22.5	77.5	15.3	4.9
1981	23.0	77.0	15.8	5.1
1982	24.7	75.3	16.9	5.7
1983	25.4	74.6	17.3	6.0
1984	25.9	74.1	17.5	5.8
1985	25.9	74.1	17.6	6.0
1986	26.8	73.2	17.9	6.1
1987	27.3	72.7	17.6	6.0
1988	26.5	73.5	17.0	5.7
1989	25.8	74.2	16.5	5.5
1990	23.1	76.9	14.8	5.1
1991	19.8	80.2	12.6	4.5
1992	20.0	80.0	13.1	4.7
1993	19.8	80.2	12.4	4.3
1994	19.8	80.2	11.6	3.9
1995	17.2	82.8	10.8	3.6
1996	16.2	83.8	10.1	3.4
1997	16.1	83.9	9.3	3.2
1998	15.1	84.9	9.0	3.0
1999	14.6	85.4	8.9	2.9

Figure 2.1. Department of Defense Budget Trends

nation's unified and functional commands determine the best way to accomplish and enact a military strategy that responds to threats to U.S. national interests. The Defense Resource Board's programming priorities, requirements and advice are passed onto the Secretary of Defense, who, with the help of his Comptroller, other staff, and the Office of Management and Budget (OMB) decide how best to match resources to priorities. Ultimately, the Defense Secretary's "Defense Planning Guidance" is produced which gives a broad picture by functional category of how fiscal resources should be focused to respond to threats. This is accompanied by the Future Years Defense Plan (FYDP) which is a detailed data base showing resource allocation that not only cover the upcoming two fiscal years to be approved by Congress, but also a tentative plan for future spending for four additional years.

In the Programming phase, the CINCs, Service Chiefs, and Resource Sponsors try to best answer the question: "How much defense can we afford," by submitting conceptual plans which attempt to look for the best and most cost efficient ways to allocate resources, and the optimal way to structure our military forces to accomplish the national military strategy. The Program Objectives Memorandum (POM) is each services' plan to accomplish this. The finished product is capped by the Secretary of Defense's Program Decision Memorandum which approves the POM with exceptions. In the case of the Flying Hour Program, broad questions are considered such as how much to fly, how many aircraft should be authorized, and what structure should future Naval Aviation forces possess. All are debated within the confines of trying to meet the goals of the National Military Strategy and the Defense Planning Guidance.

Once the POM has been developed and approved, the Budgeting Phase of PPBS begins. In the case of the Flying Hour Program, this is where Resource Sponsors such as Commander Naval Air Systems Command (NAVAIR), the Commander Naval Supply Command (NAVSUP), and major claimants such as Naval Air Forces Atlantic (AIRLANT) and Naval Air Forces Pacific (AIRPAC), and must determine their inputs to the Budget Estimate Submission, a detailed budgeting plan for the Flying Hour Program. This budget quantifies questions such as how many hours will be flown and what costs will be projected. In addition, the Resource Sponsor must gain approval from the Department of the Navy Office of the Comptroller, which must in turn gain approval for the Secretary of the Navy's budget from the Secretary of Defense and his Comptroller. Ultimately, once the budget is approved by the Secretary of Defense and the President, it is presented to Congress as part of the President's Budget. Despite the fact that staff at all

levels in DOD have spent in excess of 15 months of effort to build the President's Budget, this plan still must withstand the scrutiny and politics of the congressional legislative process. Congress must eventually approve authorization and appropriation bills for the President to sign into law. Only after the President signs the bills and funds are apportioned by OMB, DOD and the Secretary of the Navy, can appropriations actually be spent in the interests of the Flying Hour Program. [Ref. 13]

This broad outline of the PPBS and congressional budgeting illustrates that the Flying Hour Program is a small percentage of the overall DOD budget, painstakingly developed through a time consuming process. These factors limit the ability of FHP guardians to make significant changes in spending without considerable political clout. In addition, the lengthiness of the process means that programmers must make decisions about the Flying Hour Program in their POM submissions up to three years ahead of when funding will be received. In that time, major strategic, logistical and economic changes can and do occur. For example, during Fiscal Year 1998, while Congress debated over the President's Fiscal Year 1999 budget, the Department of Defense spent the majority of its effort producing the Program Objectives Memorandum for Fiscal Year 2000 and 2001, and in addition incorporated planning for Fiscal Years 2002 through 2005.

While the Flying Hour Program is exceedingly complex because of the total input variables that produce its cost projections, planners, programmers and budgeteers must also deal with variables of uncertainty unrelated even to congressional and Department of Defense politics. These include the uncertainty related to national economic and national security factors ranging from the health of the international economy, inflation rates, government revenue collection, to emerging international security threats.

1. N-88 and Flying Hour Program Budget Formulation

Within the Department of the Navy, the billet with primary responsibility for guiding the Flying Hour Program through PPBS is the Special Assistant for the Flying Hour Program (N-88F), serving under the Deputy Chief of Naval Operations for Resources, Warfare Requirements and Assessments, N-8. N88F is where the attempt is made to meet the operational needs of Navy and Marine Corps Aviation with a viable and executable funding program. In other words, the Special Assistant to the Flying Hour Program has the task of presenting the operating force requirements for the Flying Hour Program to NAVCOMPT (Assistant Secretary of the Navy, Office of Budget) during the Department of the Navy budget review and trying to produce an adequate, realistic, and

sustainable budget that can withstand the scrutiny not only of Department of the Navy analysts, but also that of the Department of Defense and Congress. [Ref. 14]

With so many layers of bureaucracy involved in resource planning, so many input variables, and so few resources, it is easy to understand how budget requests for adequate funding are never just a simple matter of adherence to formulas and financial models. In relating this broad process to this thesis and Marine Forces Atlantic, two main points are important. First, even the most critical issues at Marine Forces Atlantic may not be pressing at the Department of the Navy level. Second, managers of flying hour funds need to be able to accurately predict and justify their budgets well in order to withstand the competition of the PPBS process. Failure to accurately predict costs or defend against budget marks that may take away funding can lead to difficulties well into the future for aviation commands. Therefore, to accurately predict costs, flying hour program managers must understand their program cost behavior. Once they receive funding, they must adequately manage the allocations given to them in the coming year, lest they lose credibility, which can lead to a future loss of resources.

D. THE USE OF FINANCIAL MODELS AND THE FLYING HOUR PROGRAM

Since understanding Flying Hour Program cost behavior is essential to effective management of Flying Hour Program funding, this section reviews the basic Flying Hour Program financial models that N-88F uses to produce its annual budget. At the risk of oversimplification, this section attempts to provide a basic understanding of the significant cost categories and predictive models used in the OP-20. As mentioned in the beginning of the chapter, the term "OP-20" is simply a code for one of many Department of the Navy budget exhibits for Navy Operations and Maintenance (O&M,N) appropriations ranging from the OP-5 (budget detail by activity and subactivity) and OP-32 (summary of price and program changes), the most significant O&M,N budget exhibits, to OP-71, a budget exhibit for Organization Clothing and Equipment. [Ref. 15]

The OP-20 can be broken down into several predictive models. However, this research focuses on the most significant models through which MARFORLANT receives the majority of its FHP funding. The explanation of these predictive models is separated into six sections: 1) Major OP-20 Flight Hour Categories, 2) Breakdown of OP-20 back up exhibits, 3) the TACAIR OP-20 model, 4) the Fleet Air Training Model, 5) Other OP-20 Sections, and 6) OP-20 Breakdown of Cost Per Hour.

1. Major OP-20 Flight Hour Categories

Whether a version of an OP-20 model is being generated for future planning as part of the POM, part of the President's Budget headed to Capitol Hill for debate, or is part of the N-88 execution plan for the beginning of a new fiscal year, the FHP addresses flight hour projections and costs in five major categories by function:

Category	***Mission***
1. TACAIR/ASW	Deployable combat squadrons for national defense.
2. Fleet Air Training	Post graduate fleet replacement training squadrons.
3. Fleet Air Support	Deployable and non-deployable support units.
4. Undergraduate Training	Pilot and Naval Flight Officer basic training.
5. Reserve [Ref. 16]	Navy and Marine Corps aviation reserve units.

These categories reveal the complexity of the Flying Hour Program in the process of delineating the different types of flying that occurs within the Department of the Navy. For example, different models and series of the CH-53 may see service in four of the five categories listed: flying tactical helicopter support in a combat squadron as part of TACAIR, as a training aircraft for pilots receiving their initial training prior to joining a deploying squadron, as part of HMX-1 performing duties in support of the President of the United States, or in Reserve units across the United States performing training missions similar to TACAIR squadrons. The same type of aircraft may fly in all the four categories. However, the missions that it supports, and thus the cost of supporting the aircraft in the different categories, may differ.

2. OP-20 Back-Up Exhibits

Although the OP-20 at its macro level becomes an aggregate of cost projections by Program Element and Type/Model/Series of aircraft, it is more useful when broken down by Major Claimant into the five major flight hour categories by Type/Model/Series of aircraft. The two primary backup exhibits are:

Schedule Name	*Purpose*
1. Schedule A	TACAIR/ASW flight hour requirements.
2. Schedule B	Training flight hour requirements.

3. The TACAIR OP-20 Model

An example of the OP-20 TACAIR model used to project flight hours and budgeted cost is listed below:

T/M/S	*PAA*		*CSR*		*AMF*		*REQUIRED H/M/C*		*MONTHS*		*REQUIRED HOURS*
AV-8B	80	x	1.4	x	.98	x	25	x	12	=	32,928

REQUIRED HOURS		*PMR*		*BUDGETED HOURS*		*CPH*		*BUDGET*
32,928	x	.7802	=	25,692	x	$2,844.71	=	$73.086M

This example shows how estimated annual flight hours are determined for the AV-8B Harrier. Once the required flight hours have been determined, they are multiplied by the pre-determined Primary Mission Readiness constant (traditionally 85%) agreed to by the Navy, DOD and Congress. They are then deployed by the estimated cost per hour for the coming budget year. The resulting dollar figure is the estimated dollars that this type of aircraft is expected to use for the particular activity it is flying. The formula is the same whether at the macro level, such as the Department of the Navy, or below the type commander level such as at the 2nd Marine Aircraft Wing.

The following list explains the individual components of the model in greater detail:

Type/Model/Series (T/M/S):

Represents the type of aircraft and its current model. For example, there are significant differences in the design of the F/A-18C vs. the F/A-18D.

Primary Aircraft Authorized (PAA):

Represents the number of primary aircraft authorized by Resource Sponsors and Aviation Master Plans for a particular level of budgeting. It is not to be confused with the number of aircraft assigned to a unit.

Crew-Seat-Ratio (CSR):

Is the ratio applied to the number of aircraft which represents the number of pilots per aircraft determined necessary to man a given T/M/S in a squadron.

Aircrew Manning Factor (AMF):

Is the reduction factor in the OP-20 model. This variable adjusts for differences between budgeted crews and actual aircrew, and represents the current percentage of a given unit's table of organization that is actually manned.

Required Hours per Model per Crew:

Is the pre-determined number of flight hours per month determined by a service's Training and Readiness Manual (T&R Manual) that one aircrew needs per month to meet their units and professional flying hour requirements. Navy and Marine TACAIR units differ in their approach to generating this figure. Navy TACAIR H/M/C is driven by a number of factors including the primary mission area of an aircraft to the priorities of a Type Commander. Marine TACAIR H/M/C is more strictly related to the requirements of each model's T&R manual.

Required Hours:

The number of hours that would allow a squadron to achieve 100% mission readiness with a designated number of pilots. The formula is CSR x AMF.

Primary Mission Readiness (PMR):

PMR = Budgeted Flight Hours/Required Flight Hours. This yields a percentage which shows the number of flight hours that Congress is willing to fund. Congress has been told by the Department of the Navy that the minimum PMR necessary in order to attain combat readiness is 85%. However, this number is often capped at 83% due to an expectation that 2% of a pilot's hours will be simulator training. PMR is not often a true readiness indicator because variations in training plans by commander, operational schedule and type of aircraft may differ. The overall expectation is that a units readiness can generally translate to its executed PMR.

Cost Per Hour (CPH):

CPH is the budgeted rate that is projected for costs for the particular Type/ Model/Series of aircraft. [Ref. 17]

4. The Fleet Air Training Model

The formula below is one typically deployed in Schedule "B" for flight hour requirements for Fleet Air Training of different types.

T/M/S	*NUMBER OF A/C*	*CAT*	*NO PILOTS*	*SYL HRS*	*PILOT HOURS*
AV-8B	14.0	I	17@	150	2550
		III	15@	45	675
		IV	7@	15	105
TOTALS			39		3330

Fleet Air Training is somewhat less complicated to budget for since the training requirements tend to have a standard requirement related to a training syllabus. A training syllabus is a plan of required training flights that develop the flight skills of pilots in accordance with an established standard. Since the syllabus is standardized and the types of flights are known, it is relatively easy to predict the total flight hours to complete a pilot training cycle. Once total hours have been required they can once again be multiplied by the cost per hour for a particular aircraft in order to find the budgeted dollar amount for the flight hours. The example continues below.

REQUIRED HOURS	BUDGETED HOURS	COST PER HOUR	REQUIRED COST	BUDGETED COST
3330	3330	3571.26	11.892 M	11.892 M

Abbreviations for the Fleet Air Training Formula are listed below.

CAT (Pilot Training Category):

Specifies the type of training pilots are receiving based on the following five categories:

- **CAT I.** First Tour Aviator or First Tour in Aircraft Type. Receives 100% of syllabus.
- **CAT II.** Usually second tour in Type Aircraft. Receives approximately 75% of CAT I syllabus.
- **CAT III.** Third Tour or Transition from one aircraft type to another. Receives approximately 50% of CAT I syllabus.

- **CAT IV.** A quick NATOPS (Naval Air Training and Operating Procedures Standardization) check in order to verify the pilot has enough training to safely operate the aircraft without supervision.

- **CAT V.** A specialized syllabus for foreign officers or transition from fixed wing to helo requiring 25% to 75% of original syllabus. [Ref 18]

5. Other OP-20 Sections

The OP-20 carries budget projections for Fleet Air Support, Undergraduate Training and Reserve Forces as well. However, except for discussing MARFORLANT's allocations of FHP funds for Fleet Air Support, the scope of this thesis will not detail budgeting for these categories. [Ref. 19]

6. OP-20 Breakdown of Cost Per Hour and Total Budgeted Cost

Of all the sections of the OP-20 explained thus far, the determination of Cost Per Hour and Total Budgeted Costs is the most important exhibit for the Flying Hour Program. The previous examples showed that the budgeted flight hours were multiplied by the cost per hour for a particular aircraft type depending on cost category (TACAIR, Fleet Air Training, etc) for a particular Type/Model/Series.

The examples for TACAIR and Fleet Air Training displayed the budgeted flight hours multiplied by a Cost Per Hour determined by the Special Assistant for the Flying Hour Program. Although Cost Per Hour is the final, combined standard cost to be multiplied by flight hours, its composition is very complex and will be the subject of further analysis in the thesis. Basically, Cost Per Hour is the total cost to operate a particular type model and series of aircraft. An example formula from the OP-20 describes the model's compilation of different cost categories into a single cost per hour by Type/Model/Series.

TMS	*FORCES*	*UTIL*	*HOURS*	
AV-8B	60.0	19.339	13924	
COST PER HOUR				
FUEL	*DLR*	*MNT*	*TOT*	
629.14	2224.61	888.30	3742.05	
ANNUAL COST IN MILLIONS				
FUEL	*DLR*	*MNT*	*TOTAL*	*HOURLY FUEL*
CONS. RATE				
8.760	30.975	12.369	52.104	16.103

Forces:

The number of primary aircraft by T/M/S authorized for use in the formula.

Utilization Rate (UTIL):

Utilization Rate is the pre-determined hours per month that one aircraft is budgeted to fly. This can be determined by the formula: Utilization Rate= Budgeted Flight Hours/(Forces for T/M/S)(12 months).

Hours:

Hours stands for Budgeted Hours as shown earlier in the TACAIR and Fleet Air Training Models.

Fuel Cost Per Hour:

Annual cost of fuel is determined by (fuel consumption rate for the particular T/M/S) x (cost per composite barrel of fuel) x (budgeted annual flight hours). Cost per composite barrel of fuel usually is determined by Type Commanders and most often relates to a mix of JP4 and JP5, although JP8 and commercially available fuel can also be purchased. Fuel consumption rates are expressed in barrels/hour, e.g., 42 gal/barrel. *Fuel Cost Per Hour* = Total Budgeted Fuel Cost/Budgeted Hours. [Ref. 20]

Depot Level Repairables(DLR)Cost Per Hour:

More correctly known as aviation depot level repairables(AVDLR), DLR is the most expensive of the three Flying Hour Program cost categories. (POL, MNT, DLR) It refers to costs incurred by repairing major components of aircraft or weapons systems that must go to a depot or contractor because repairing the aircraft is either beyond the capability of an aviation unit's organic or support maintenance, or is simply uneconomical to repair at those levels. [Ref. 21] DLR(Cost per Hour) = Total Budgeted DLR Costs/Budgeted Flight Hours.

Maintenance(MNT) Cost Per Hour:

MNT is an abbreviation that stands for Aviation Fleet Maintenance or AFM. Ideally, this cost category captures maintenance performed at Organizational and Intermediate Maintenance levels. Organizational Maintenance (OMA) costs include consumables such as paints, rags, cleaning agents and consumable parts for the periodic maintenance of the aircraft. Intermediate Maintenance (IMA) costs relate more to complete repair of major aircraft components. For both categories tools, flight

equipment, and safety items are included. MNT(Cost per Hour) = Total Budgeted MNT Costs/ Budgeted Flight Hours. [Ref. 22]

The rest of the formula is *Total Cost Per Hour* equaling the addition of all three sub-cost categories. Also, costs can be analyzed by their total cost on the OP-20 in millions of dollars.

These are basics of the OP-20 budgeting model. More complex are the deliberations and data collection efforts that go into determining what budgeted costs and flight hours will be for a coming fiscal year. The resource politics of PPBS play a part in the outcome of the rates, but there is also considerable annual controversy about the best way to predict costs captured from previous years within the system. In review, flight hours are used as the basic metric to measure all costs from fuel to depot level repairables, even though the determination of budgeted flight hours differs for categories such as TACAIR versus Fleet Air Training.

E. PREDICTION OF COSTS IN THE OP-20 MODEL

Historical costs in each major Flying Hour Program cost category are tracked in the Flying Hour Program Projection System (FHPS) that is physically located at the Naval Inventory Control Point (NAVICP-M) in Mechanicsburg, Pennslyvania. [Ref. 23] Over time, N-88 has worked to refine its formulas predicting costs in future years. The former N-889 method for determining budgeted Cost Per Hour was to use a three-year moving average from the Naval Air Type Commands to smooth aberrant cost fluctuations in the historical data. A quote from a former Special Assistant to the Flying Hour Program explains:

> For example, to obtain the 1993 CPH figures released on the POM OP-20 in June, 1992, N889E took the 1989, 1990, and 1991 *actual* fiscal year expenditure totals by cost pool and the total flight hours flown from both the Navy's cost accounting system and the FHCRS (Flying Hour Cost Report System), manipulated these figures to achieve a three-year average in 1992 dollars, then applied the applicable 7111 (NAVCOMPT Notice 7111) escalators for inflation/deflation. [Ref. 24]

However, escalation of aviation costs has been so prevalent in the last several years that N889E has switched to taking the previous year's cost data with predicted inflation/ deflation indices applied because of the unpredictability of FHP costs.

In summary, as basic as the OP-20 model may be, the model is only simple from a descriptive viewpoint. Both historical and current research reveals the incredibly

complex operational and logistical system that is used to build and execute the entire budget mechanism based on the Cost per Flight Hour model. Again, the often repeated question about this formula is: Does the OP-20 budgeting model accurately predict what the annual costs of the Flying Hour Program will be? The answer to this question is that it does not predict annual costs accurately. The next section reviews relevant Flying Hour Program research and other analysis of the Flying Hour Program to use as deductive benchmarks for analysis later in the thesis.

F. KEY CONCLUSIONS FROM PREVIOUS FHP RESEARCH

This section is broken into two parts. The first reviews literature relevant to this thesis where quantitative analysis has attempted to develop a better predictive model for the Flying Hour Program than the OP-20 models. The second section reviews literature that provides qualitative benchmarks for the Flying Hour Program including Simons' framework for his book Levers of Control.

1. Previous Quantitative Analysis of the Flying Hour Program

Three previous research efforts were reviewed to develop the quantitative framework for this research. The first was research conducted by Byrne at the Naval Postgraduate School in 1987. Her thesis, Analysis of the Aircraft Flying Hour Program at the Pacific Missile Test Center, attempted to build a model derived from monthly cost data to predict aircraft cost rates for the Pacific Missile Test Center. Using flight hours as an independent variable, a regression was conducted against fuel costs. The analysis was conducted separately for cost data on 9 different types of aircraft. Although the thesis claimed there was a strong correlation between fuel consumed per hour by the aircraft and actual flight hours, only the F-14 aircraft showed a correlation that explained more than 75 percent of the relationship. A similar regression of flight hours versus parts cost by Byrne showed no correlation between the cost and consumption of parts and the number of flight hours flown. Bryne concluded that maintenance costs needed to be charged as a fixed rate for Pacific Missile Test Center customers. All data were adjusted for inflation and smoothed using a moving average to compensate for the inexact timing of when costs were recorded. To summarize the key points of this thesis were:

1. Fuel costs showed some correlation to flight hours, but 25 to 75 percent of the relationship between the two variables was unexplained. (See Figure 2.2)

2. Maintenance costs for parts showed no correlation to flight hours, and was assumed to be a fixed cost of operations. [Ref. 25]

Type	A3	A6	A7	F4	F14	F18	H46	C12	P3
R^2	34%	27%	49%	47%	76%	20%	20%	45%	56%

Figure 2.2. R^2 by Aircraft Type at Pacific Missile Test Center [Ref. 22]

In 1994, another Naval Postgraduate School student wrote <u>Modeling F/A-18 Flight Hour Program Costs Using Regression Analysis</u>. In this research, Arkley conducted a regression analysis of F/A-18 cost data from the Navy and Marine Corps Reserve. His goal was to develop a mathematical model that would allow financial managers to predict total end of fiscal year costs with only 2 or 3 months of actual execution data. Like Byrne, Arkley regressed flight hours as the independent variable against four separate components of cost data for the F/A-18: Fuel Costs, Organizational Maintenance Costs (OMA), Intermediate Maintenance Costs (IMA), and Aviation Depot Level Maintenance Costs (AVDLR). Studying reserve unit aviation cost behavior in this way was unique because active duty unit costs are not tracked at the same level of detail as reserve costs. As described earlier in this chapter, active duty cost records combine OMA and IMA costs into one category: MNT.

Like Bryne, Arkley adjusted his cost data for inflation rates and the variable cost of fuel. However, for IMA and AVDLR costs Arkley also adjusted his data for changes in annual Defense Business Operation Fund rates (DBOF…now Navy Working Capital Funds) and for increased costs due to decreased jet engine life cycle times. Arkley's regression results showed very strong correlation between flight hour and fuel costs, and between flight hours and OMA costs. Even IMA and AVDLR costs showed a much stronger correlation than Bryne's research. A summary of Arkley's results are shown below:

Cost Pool	Minimum Group R^2	Maximum Group R^2
Fuel Cost vs. Flight Hours	93.8%	100%
OMA Cost vs. Flight Hours	48.8%	97.8%
IMA Cost vs. Flight Hours	59.3%	94.1%
DLR Cost vs. Flight Hours	67.9%	96.0%

Figure 2.3. Averaged Regression Results for Reserve F/A-18s [Ref. 27]

Figure 2.3 demonstrates that Arkley was able to more successfully adjust the data to identify relationships between cost pools. Fuel and OMA Costs, as expected, were quite high. However, even regression of Depot Level Repariables was much stronger than expected considering Byrne's results. In Arkley's conclusion, he attributed some of this success to the fact that the Reserves are able to more accurately capture the data because of their cost pools, and also because of their operating procedures. For example, Reserve aircraft fuel is immediately paid for before fueling an aircraft flight. Therefore, the costs are tracked more accurately. In addition, the Reserve units were much more likely to use one fuel rate, and had less chance that free fuel was mixed into the fuel counted as paid.

In summary; the following assumptions from Arkley may be applied as benchmarks for this thesis:

1. Fuel and OMA costs fit significantly when analyzing the variable relationship between flight hours and these cost pools.

2. IMA costs often show less statistical significance when regressed versus flight hours because of maintenance time lags and work that can be repaired by other commands at other locations.

3. DLR cost can show strong statistical significance, if data is adjusted properly.

Other previous quantitative research relevant to this thesis was a 1997-98 study by the Naval Center for Cost Analysis, to "investigate near and long term solutions for FHP 'pricing methodology' and 'requirements validation'." "The goal of the study requested by the CNO was to try to develop a better model to ensure that the FHP was "properly resourced,...executable, balanced, and fully defensible with OSD and the Congress." [Ref. 28] This study was successful in building a model that developed a regression formula for total program costs, using total FHP cost as the dependent variable and total flight hours as the independent variable. NCCA also was able to find statistically significant relationships for total cost data from AIRPAC and AIRLANT. They were unable to develop statistically significant relationships for any other sub-claimant or claimant levels, nor were they able to define and vailidate models using other data sets that reflected aircraft age, number of T/M/S aircraft, number of sorties flown, or by specific service. Reserve units were not included in this data base. In summary, the NCCA conclusions relevant to this thesis are:

1. Regression analysis can yield a statistically significant relationship which reflects total cost vs. flight hours at the Department of the Navy level.

2. Comparisons of NCCA model versus OP-20 POM predictions for budget outyears showed that the Department of the Navy was underestimating the future cost of the program. [Ref. 29]

3. Fuel costs showed a variable relationship with flight hours, consumables showed a fixed plus variable relationship, while AVDLR costs did not show any significant relationship to number of hours and was modeled as a fixed cost.[Ref. 30]

2. Previous Qualitative Analysis of the Flying Hour Program

A number of Naval Postgraduate School theses have been written addressing qualitative aspects of the Flying Hour Program. Most theses that did not have a quantitative analytical methodology addressed the workings of the Flying Hour Program only at the Department of the Navy, CNO or Type Commander Level (e.g., AIRLANT, AIRPAC). One of the most useful in preparation for this thesis was <u>Flight Hour Costing at the Type Commander and Navy Staff Levels: An Analytical Assessment</u> by Edwards (1992). This thesis explained budgeting and execution in precise detail. Although some of the information has become outdated, it is still a fundamentally strong attempt to map the process.

Key conclusions from the Edwards thesis include:

1. An assessment that assets were being over-used without resource management necessary to replace aging aircraft and equipment. [Ref. 31]

2. Questions about the suitability of Cost Per Hour as a reflection of Flying Hour Program Costs, especially because of the volatility of maintenance procedures and the difficulty of accurate cost collection.

An additional source that provides insight into recurring complaints from Congress about the Flying Hour Program is a General Accounting Office (GAO) report of July 1989: <u>The Flying Hour Program's Budget and Execution</u>. [Ref. 32] Despite the fact that this report is nearly ten years old, many NPS theses written afterwards reported and expanded upon the findings of this report. GAO was asked by Congress in this report to evaluate the validity of the FHP process in determining Flying Hour Program requirements and trends, and to examine whether execution reflected budget requests. Although

many critics in the Navy and Marine Corps take issue with the findings in this report because of its simplistic and overly critical approach, the report nevertheless exposes weaknesses in the FHP from an independent perspective. The key finding in this report relevant to this thesis is that the GAO believed the program: "lacked objective budget estimates and performance goals" [Ref. 33]. In essence, the report complained that funds requested were not easily linked to a pre-determined level of readiness. For example, the Navy stated that aircrews for F-14 Tomcats required 25 hours of flight training per month, yet there was no study to prove that these established requirements were actually valid.

These reviews of previous analysis are important to the thesis because they provide points of reference for the next chapter that surveys the Flying Hour Program at MARFORLANT, and for the results from this research analysis. However, before moving to Chapter III, a framework for analyzing the organization of the Flying Hour Program and the Marine Aviation Campaign Plan must be defined.

3. A Framework for Analysis of FHP as a Management Control System

Simons' findings about the way managers implement strategic decisions through management control systems is explained in his book Levers of Control. [Ref. 28] According to Simons, a management control system is the, "formal information based routines and procedures managers use to maintain or alter patterns in organizational activities." [Ref. 34] In attempting to prescribe how the MARFORLANT Aviation Budget Officer should best manage the FHP at his level, this framework appears to be useful. The Flying Hour Program reflects Simons description of a management control system in that it provides managers at all levels information about the requirements and execution of aviation budgets, and supports operations necessary to accomplish the mission of Navy and Marine Corps aviation.

Simons' criticism on the strategies that organizations should execute is that not much has been discussed about how strategies are implemented and monitored for success. For example, a Flying Hour Program budget from an OP-20 is an annual strategy. However, it must be executed successfully. In this type of situation Simons presents "how to manage tensions between freedom and constraint, empowerment and accountability, and top down direction versus bottom up creativity." [Ref. 35] These tensions are classified into four separate management control categories: belief systems, boundary systems, diagnostic control systems, and interactive control systems.

A *beliefs system* is, "the explicit set of organizational definitions that senior managers communicate formally and reinforce systematically to provide basic values, purpose, and direction for the organization." [Ref. 36] This type of system is often communicated through documents and other forms of communication which impart this vision to members of the organization. "The primary purpose of a beliefs system is to inspire and guide organizational search and discovery. When problems arise in implementing strategy, a beliefs system helps participants to determine the types of problems to tackle and the solutions to search for." [Ref. 37] Military examples of beliefs systems relevant to this thesis include the Marine Corps core values of "honor, courage, and commitment," or the vision the Marine Aviation Campaign Plan has for maintaining current readiness without jeopardizing future readiness.

Boundary systems "impose important limits on the organizational search activity motivated by beliefs systems." [Ref. 38] In other words, they establish limits to the search for solutions to problems. "Although boundary systems are essentially proscriptive or negative systems, they allow managers to delegate decision making and thereby allow the organization to achieve maximum flexibility and creativity." [Ref. 39] The laws described in the Uniform Code of Military Justice are examples of very formalized boundary systems. However, there are also boundary systems with less formalized limits, such as the mark and reclama process to budget submissions in PPBS.

Diagnostic control systems provide feedback to managers about whether a specific goal is being achieved. "These feedback systems, which are the backbone of traditional management control, are designed to ensure predictable goal achievement." [Ref. 40] "Three features distinguish diagnostic control systems: (1) the ability to measure the outputs of a process, (2) the existence of predetermined standards against which actual results can be compared, and (3) the ability to correct deviations from standards." [Ref. 41] Simons commented that diagnostic control systems could often have a "powerful" impact on organizations because of unintended consequences and incentives that often constrain innovation. Many components of the Flying Hour Program, such as readiness reports and costing systems, can be described as diagnostic control systems.

Interactive control systems are the opposite of diagnostic control systems because they help managers to deal with strategic uncertainty. "These systems stimulate search and learning, allowing new strategies to emerge as participants throughout the organization respond to perceived opportunities and threats." [Ref. 42] According to

Simons, interactive control systems have four "defining characteristics: 1) information generated by the system is an important and recurring agenda addressed by the highest levels of management, 2) the interactive control system demands frequent and regular attention from operating managers at all levels of the organization, 3) data generated by the system are interpreted and discussed in face-to-face meetings of superiors, subordinates, and peers, and 4) the system is a catalyst for the continual challenge and debate of underlying data, assumptions, and action plans." [Ref. 43] The Flying Hour Program and specific components of the Marine Aviation Campaign Plan are examples of interactive control systems.

Much of Simons' work discusses the interaction of these four separate types of control systems. Oftentimes, one system works in opposition to the other. An important lesson of Simons' book is understanding how to balance and align these control systems to successfully achieve the goals of an organization. Figure 2.4 depicts Simons' management control systems and their relation to an analyzed management strategy.

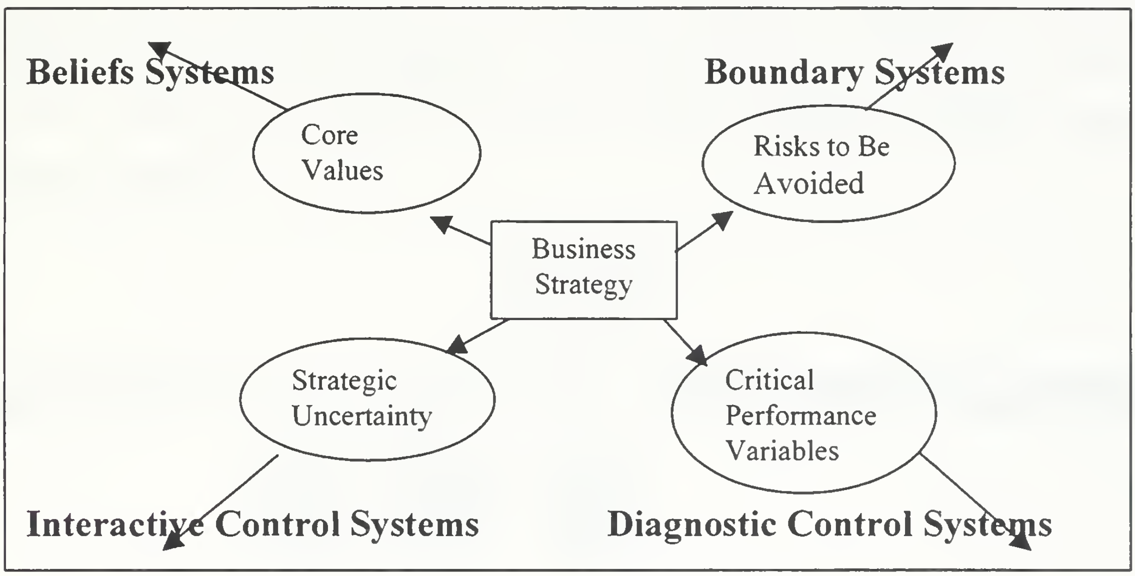


Figure 2.4. Controlling Business Strategy: Key Variables To Be Analyzed

The NCCA Cost Analysis, Byrne's thesis and Arkley's thesis combined the organizational ideas of Edwards and Simons, provide rich background and robust ideas to

use in analysis of the FHP at MARFORLANT. A further discussion of the research methodology is provided in Chapter IV.

G. SUMMARY

This chapter strives to give the reader the basic tools necessary to understand the remainder of the thesis. Federal budgeting was analyzed to provide an overall perspective on the dynamics and limitations of the federal budget process relative to the Flying Hour Program. The Planning Programming and Budgeting System sets similar constraints for the Flying Hour Program, in particular because of the length and complexity of the PPBS and budget processes. The basic OP-20 model was explained to provide background for regression analysis. The literature review was conducted in order to develop hypotheses or assumptions about the Flying Hour Program defined from previous research.

III. MARINE AVIATION, MACP AND MARFORLANT

This chapter focuses specifically on the background issues and problems with the Flying Hour Program and Marine Corps Aviation. It explains the operational and administrative organization of MARFORLANT relevant to the administration of the Flying Hour Program, the duties of the MARFORLANT Aviation Budget Officer, problems facing the FHP at MARFORLANT, and an overview of the Marine Aviation Campaign Plan.

A. ORGANIZATION OF MARINE AVIATION AT MARFORLANT

U.S. Marine Forces Atlantic is one of one of two major Marine Corps operational commands that provide operating forces to joint unified commands, subordinate unified commands, or joint task force commanders. In joint warfighting organization for operations, a unified command is defined as "a command with a broad continuing mission under a single commander," composed of significant assigned components of two or more military departments. The unified command is established and designated by the President through the Secretary of Defense with the advice and assistance of the Chairman of the Joint Chiefs of Staff. [Ref. 44] As Figure 3.1 illustrates, five unified commands are organized by geographical area, the other four are organized by function. These commands are the centers of operational decision making for the nation's global military capabilities.

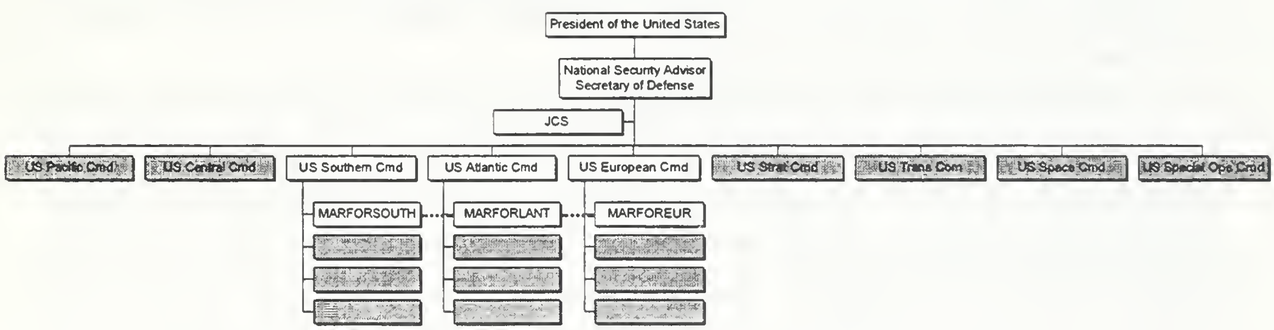


Figure 3.1. U.S. Marine Forces Atlantic within the Structure of the Unified Commands

A joint task force (JTF) is a temporary warfighting organization with a specific mission established by a unified, sub-unified or specified command. Marine forces may be assigned to a JTF or may even provide the primary structure for the JTF command element or operating forces.

MARFORLANT is the Marine Corps' component command organized under the unified combatant command, U.S. Atlantic Command (USACOM). A service component command is defined as, "a command consisting of the service component commander and all those service forces, such as individuals, units, detachments, organizations and installations under the command including the support forces, that have been assigned to a combatant command, or further assigned to a subordinate unified command or joint task force." [Ref. 45] Therefore, in a joint environment the Commander of U.S. Marine Forces Atlantic has the following responsibilities:

- To make recommendations about proper employment of Marine forces to the Joint Force Commander.
- To accomplish any operational missions assigned by the Joint Force Commander.
- To select and nominate specific units of the Marine Corps for assignment to subordinate force commands.
- To retain overall responsibility for service specific functions such as internal administration, training, logistics, and service intelligence operations.

In addition to his responsibilities to do this for USACOM, the Commander of U.S. Marine Forces Atlantic is also the component commander for U.S. European Command, and U.S. Southern Command.

To make matters more complex, because of the unique organization of the Marine Corps, which can primarily fight as part of the Navy-Marine Corps team as part of deploying units in the U.S. Atlantic Fleet, the Commander of U.S. Marine Forces Atlantic is also the Commanding General of Fleet Marine Forces, Atlantic and Europe, and U.S. Marine Corps Bases Atlantic. To summarize, MARFORLANT is a command that oversees the training, administration, maintenance and preparation for employment of all Marine Operating Forces on the east coast of the United States, and in the Atlantic, European, and Southern joint geographical areas. [Ref. 46] Figure 3.2 illustrates the command relationships of COMMARFORLANT.

Internally, MARFORLANT has two major subordinate organizations. The first is 2nd Marine Expeditionary Force (II MEF), which is the warfighting arm of MARFORLANT. II MEF is composed of 2nd Marine Division, 2nd Force Service Support

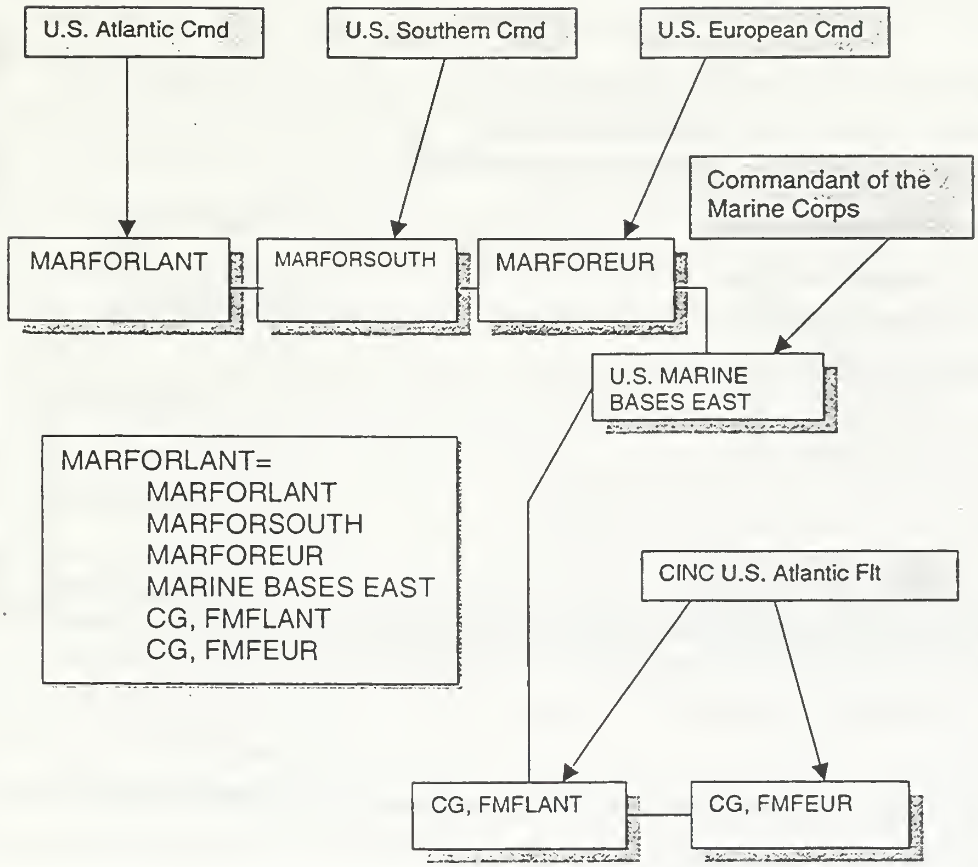


Figure 3.2. Different Command Responsibilities Held by Commander, U.S. Marine Forces Atlantic

Group, and 2nd Marine Aircraft Wing." The second is the array of Marine bases which support the operating forces. These primarily include Camp Lejeune, which is the home of the II MEF Command Element, 2nd Marine Division, and 2nd Force Service Support Group and Commander, Combined Air Bases East (COMCABEAST) which includes New River, Cherry Point, and Beaufort Marine Corps Air Stations. This is the relevant, not all inclusive organization of MARFORLANT. Figure 3.3 shows the major subordinate organizations of MARFORLANT.

From an aviation perspective, the Commander U.S. Marine Forces Atlantic has the majority of his assets organized under the Commanding General, 2nd Marine Aircraft Wing. These are closely tied with the base support structure of COMCABEAST, which receive a small percentage of aviation funding for support operations and Fleet Air Support operations. In addition, MARFORLANT funds HMX-1 in Quantico, Virginia, which primarily provides transportation support to the President of the United States.

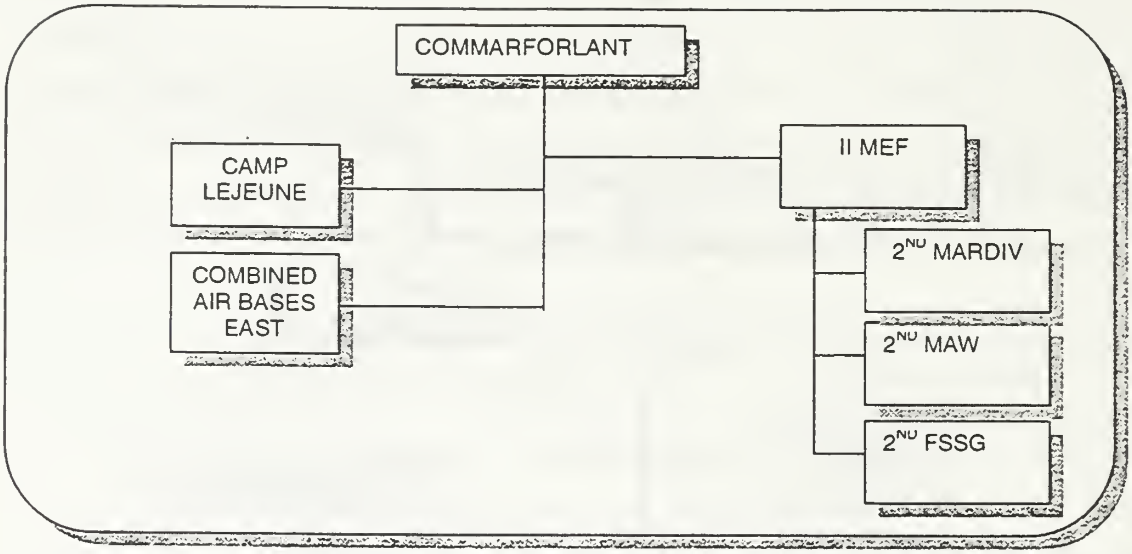


Figure 3.3. Major Subordinate Organizations of MARFORLANT [Ref. 49]

The 2nd Marine Aircraft Wing's tactical aviation and training squadrons are organized within four Marine Aircraft Groups (MAGs). These four groups, their home station and the primary T/M/S aircraft operated in the MAGs are listed below:

MAG	MCAS	Primary T/M/S
• MAG-14	Cherry Pt.	AV-8B, EA-6B, TAV-8B
• MAG-26	New River	UH-1N, AH-1W, CH-46E, CH-53E
• MAG-29	New River	UH-1N, AH-1W, CH-46E, CH-54E
• MAG-31	Beaufort	F/A-18A, F/A-18C, F/A-18D

COMCABEAST receives some funding from the Flying Hour Program to support base operations and maintenance contracts for a small arm of support aircraft. These

include the C-9B transport, and UC-12B transport aircraft, and the HH-46 and UH-1 for organic lift and search and rescue capabilities. [Ref. 47]

HMX-1 conducts helicopter support by flying the following types of aircraft: CH-46E, CH-53E, VH-3D, and VH-60N. "The VH-3 and VH-60 are used exclusively to transport the President of the United States. The CH-46 and CH-53 models have a dual mission of executive support (staff and press only) and follow-on test and evaluation," usually in conjunction with activities at Marine Corps Base Quantico, Virginia. [Ref. 48]

The continuing operations and maintenance of all these aircraft is funded by the Navy Operations and Maintenance ("Blue" dollars) appropriation. These are distributed administratively to MARFORLANT from the Commander, Naval Air Forces Atlantic Fleet (COMNAVAIRLANT), which is a Type Command organized under the Commander in Chief, U.S. Atlantic Fleet. AIRLANT is a subclaimant in the resource allocation process and is at the end of a long chain of administrative and operational commands. MARFORLANT is the central distributor of aviation funds to the Marine Aviation Combat Element at MARFORLANT. Although MARFORLANT is not an actual cost center for the spending of FHP funds, they allocate and monitor the use of FHP resources in subordinate units. (Figure 3.4)

Navy O&M funding allocated from COMNAVAIRLANT to MARFORLANT can be broken down into two broad funding categories: Flying Hour Program funds, and non-Flying Hour Program funds. Flying Hour Program funds allocated from AIRLANT fall into two Operational Target Functional Categories (OFCs): OFC-01 and OFC-50. Aircraft Flight Operations (AFO) is OFC-01 and breaks costs into two direct cost pools. Code 7B is the cost pool that captures fuel costs. Code 7F is the cost pool for aircrew flight equipment. Aircraft Operatons Maintenance is OFC-50 and contains two important maintenance cost pools: Code 7L is referred to as Aviation Fleet Maintenance because it typically contains funds for aircraft maintenance to be spent by fleet maintenance units. Code 9S is referred to as Depot Level Repairables and stands for maintenance that ordinarily is conducted by Aviation Repair Depots, outside contractors, or the aircraft manufacturer. The realities of these cost pools will be analyzed in Chapter IV and V. In practice these cost pools do not exclusively contain the costs that their titles would suggest.

Non-Flying Hour Program OPTARs allocate funds to MARFORLANT in four categories. Funding to maintain airfield equipment, such as aircraft tow vehicles, is referred to as Individual Material Readiness List (IMRL) and is allocated to OFC-09,

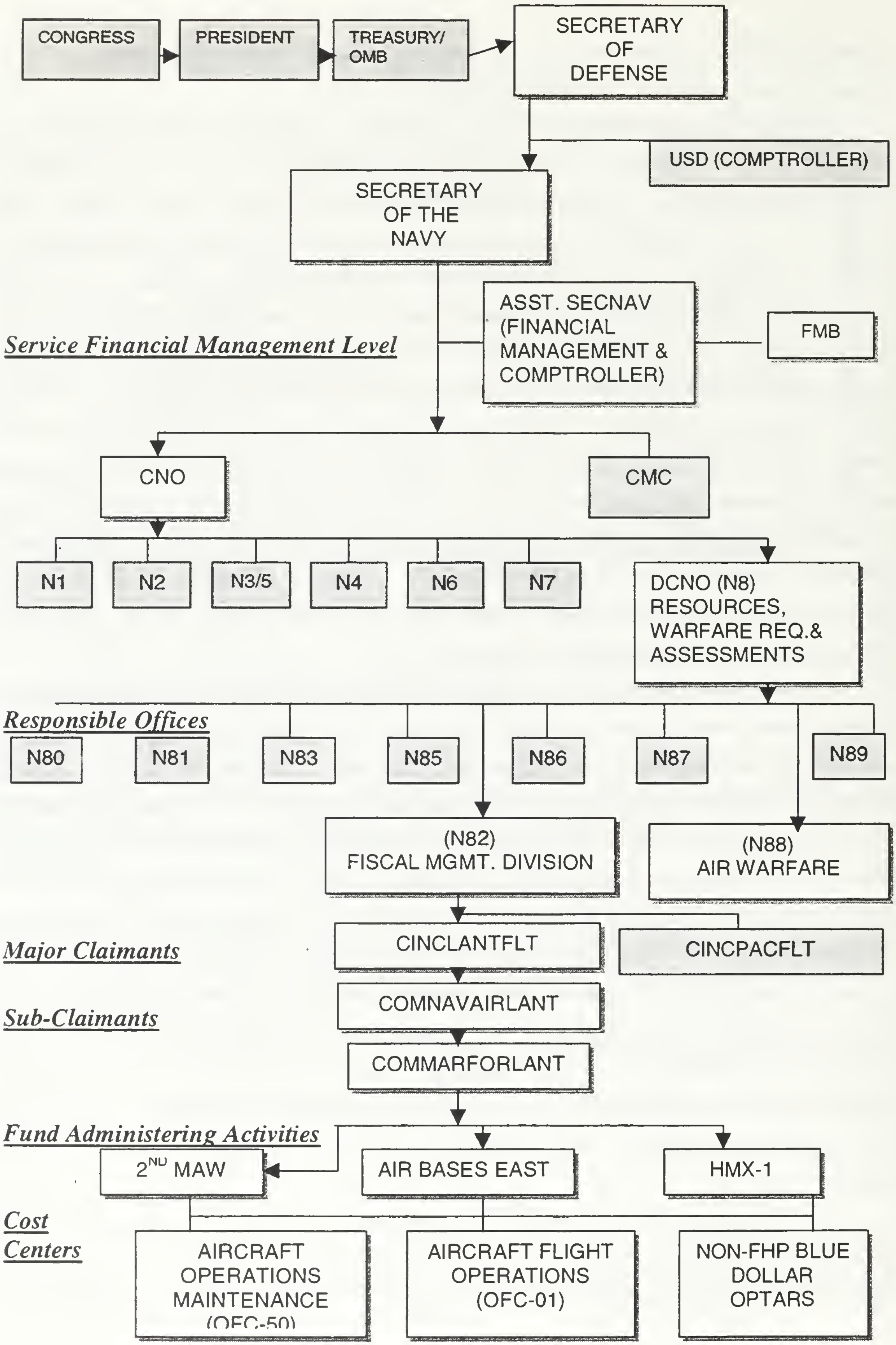


Figure 3.4 DOD FHP Financial Organization and Flow of Blue Dollars [Ref. 51]

Code 8X. Funding for Aircraft Operations Support (AC OPS) such as range fees, expenses for pre-positioning of aircraft in Norway, and different maintenance contracts related to operations support also comes from OFC-50 under Code 2F. Funding for administrative travel related to Marine Aviation is allocated from OFC-21 (TAD). Finally, funding for the movement of aircraft and personnel in the conduct of operations and training is collected under OFC 23 and is called SDT or Transportation of Things (TOT). Figure 3.5 shows the breakdown of OFCs at the MARFORLANT level and below. [Ref. 50]

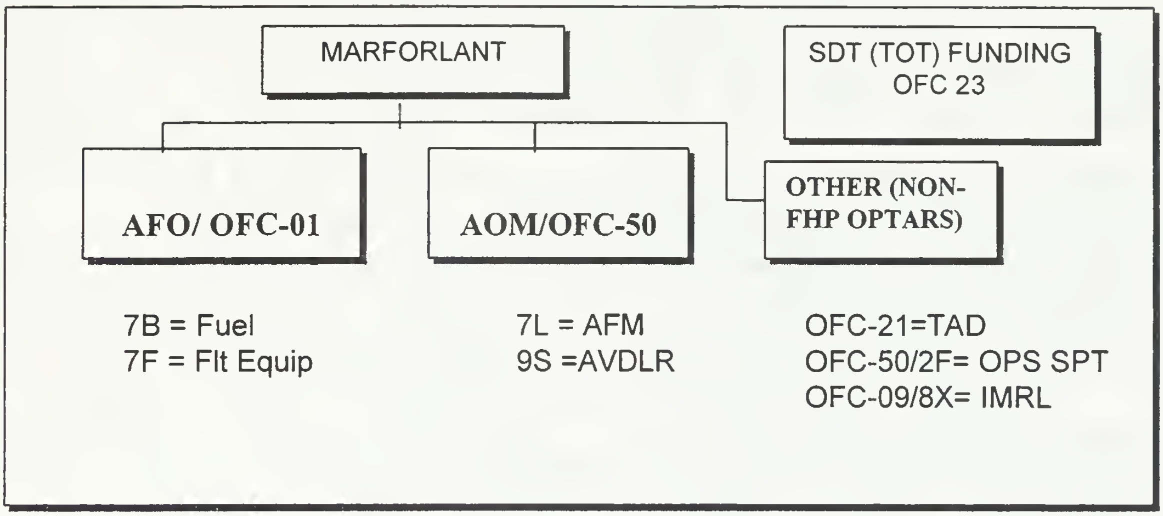


Figure 3.5. Breakdown of Operational Target Functional Categories at MARFORLANT [Ref. 52]

In summary, this section illustrates the operational and fiscal organization of MARFORLANT both externally and internally, and also illustrates the administrative flow of funding into different Operational Target Functional Categories. The process and organization has not been described in its entirety. However, this description provides a detailed enough description to comprehend the issues within the context of this thesis.

B. THE MARFORLANT AVIATION BUDGET OFFICER

Within MARFORLANT, the Aviation Budget Officer is the primary manager of funds allocated from AIRLANT. In performing his duties he has the following responsibilities:

- Makes recommendations to the Comptroller, MARFORLANT about the distribution of Navy O&M funding to subordinate aviation units.

- Monitors the spending of Navy O&M funding by subordinate units.

- Monitors the development of future OP-20s in the Defense Department Programming and Budgeting process.

- Maintains liaison with AIRLANT, N-88, and Aviation Plans and Policies (APP) at Headquarters Marine Corps regarding the interests of MARFORLANT in the programming, budgeting and execution process.

Each year, the MARFORLANT Aviation Budget Officer must coordinate with AIRLANT in both the POM budgeting and budget execution process. Once the President signs a budget and dollars are allocated to MARFORLANT into different OPTARs, the Aviation Budget Officer must also coordinate with AIRLANT and subordinate commands to determine how funds will be apportioned by fiscal year quarter, and how they will be divided by organization. In addition to dividing funds by cost pool and major organization, funds also must be set aside for transfer to Landing Force, U.S. 6th Fleet (LF6F) for use by aviation forces during deployments to the Mediterranean area, and to Marine Corps unit deployments to Japan or other operational locations. [Ref. 53]

The rest of the chapter analyzes the broad background, issues, and problems of Marine Aviation and the Flying Hour Program that the MARFORLANT Aviation Budget Officer must consider when conducting his analysis and budget recommendations.

C. MARINE AVIATION AND THE FLYING HOUR PROGRAM

In a 1995 speech, the Commandant of the Marine Corps, General Charles Krulak, commented that the Marine Corps had three essential characteristics. He stated that the Marine Corps was always naval in nature, always expeditionary as the nation's first response force, and always able to fight with combined arms. In his view, aviation was essential to fighting with combined arms. He said, "Without combined arms there is no MAGTF (Marine Air Ground Task Force)—without the MAGTF there will eventually be no Marine Corps. The Marine Corps without Marine aviation is simply a non-starter!" [Ref. 54]

Like so many facets of the Marine Corps, this is true not only because of the unique organization and capability of the MAGTF, but also because of innovative ideas about aviation that the Marine Corps has effectively applied in battle. In the past, Marine aviators pioneered close air support techniques as a devastating and accurate method of fire support. Equally important was the development of aerial envelopment doctrine using helicopters during amphibious assaults. In the present, Marine Expeditionary Units

(MEUs) as part of Amphibious Ready Groups have been continually deployed to trouble spots throughout the world. The end of the Cold War and the increase in regional instability has meant that MEUs rate of involvement in crisis operations during the 1990s has risen. The need for a responsive force for small crisis operations and for a more traditional conventional force in readiness highlight the demand for well trained aviators and well maintained equipment. In the future, Marine Aviation will remain relevant to the Marine Corps. The fielding of the V-22 Osprey begins in MARFORLANT next year. Recent warfighting experiments have shown how the range of the Osprey will allow battlefield commanders to project amphibious combat power faster and farther than ever before. Just as the introduction of the helicopter changed the techniques of amphibious combat over 50 years ago, the Osprey will also spur innovative new tactics and techniques for amphibious warfare.

In achieving these visions and accomplishing the Marine Corps core mission, there is little distinction between peacetime and wartime readiness. The Marine Corps and Marine Aviation must be ready all the time. To be ready, Marine Aviation needs sufficient "blue dollar" funding through the Flying Hour Program. As Chapter II illustrated, Marine aircraft are inextricably a part of Naval Aviation. From the allocation of resources, to the training of new pilots, to the aviation supply system, the Marine Corps is dependent upon Department of the Navy resources to perform its mission. A comparison of the total dollars going to Navy versus Marine Corps units highlights the fact that Marine concerns can be lost in the overall OP-20 budget model.

From an administrative perspective, consider the layers of administrative commands illustrated in Figure 3.4 between MARFORLANT and the administrators of the Flying Hour Program at NAVAIR. Between the time that authorization and appropriation bills are signed by the President of the United States, to the time that squadron OPTARs (Operating Targets) are determined, the funds allocated to Marine squadrons and air stations may be reduced because higher financial echelons establish reserves for budgeting contingencies levied by DOD comptrollers.

Likewise, from the perspective of the relative size and influence of aviation budgets, MARFORLANT's Flying Hour Program is small compared to AIRLANT's, from which East Coast Marine Aviation receives its funding. Figure 3.6 illustrates how aviation funding is divided between the Navy and Marine Corps at the AIRLANT level. The graph shows that the Marine Corps received less than one third of AIRLANT's resources. In 1998, Operations and Maintenance, Navy authorizations for MARFORLANT aviation totaled 411 million dollars, a mere 29% of AIRLANT's 1.41

billion dollar 1998 budget. [Ref. 55] On the other hand from the perspective of MARFORLANT, Navy Operations and Maintenance funds accounted for nearly half of the entire MARFORLANT budget. Figure 3.7 shows a comparison of Blue versus Green (Operations and Maintenance, Marine Corps) funds at MARFORLANT. [Ref. 56]

Figure 3.6. Comparison of FY 98 Aviation Funding between MARFORLANT ACE and COMNAVAIRLANT (in millions)

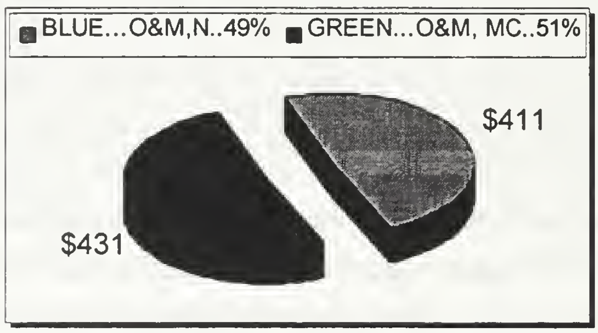


Figure 3.7. FY98 Blue vs. Green Dollars at MARFORLANT (in millions)

Flying Hour Funding at MARFORLANT allows Marine Aviation to maintain a pre-eminent position in the U.S. military and in the world as a relevant and reliable air combat element that can project power for Marines in short notice crisis situations.

D. FHP PROBLEMS WHICH THREATEN MARFORLANT FUNDING

In the 1990s, the MARFORLANT aviation budget has been threatened by several different problems. All seem to be inherent to the entire Flying Hour Program. However, that does not mean they have any less impact on MARFORLANT Aviation. In fact, they can be more of a problem for the Marine Corps because of the relative size of Marine Aviation. A combination of complex variables that are difficult to predict such as parts

failure rates, cash shortages in Navy Working Capital Funds, and backlash effects from budget tightening measures have caused these problems to occur across the spectrum of Naval Aviation.

Some of the problems listed below were addressed by the Naval Aviation Maintenance and Supply Readiness (AMSR) group that met in April 1998. AMSR was a joint team of Navy, Marine, and other DOD managers who met in San Diego, California to discuss the problems driving up the cost and driving down the readiness of naval aviation. The team identified 18 separate issues that required study and solutions to increase material readiness and decrease cost. [Ref. 57]

1. Failure of OP-20 to Accurately Predict Costs

Since the OP-20 model formerly used a three year moving average to predict costs, the smoothing of historical cost data was close to annual costs of the Flying Hour Program. This "smoothing" of the data using a moving average also meant that predicted costs lagged behind actual costs, especially as Naval Aircraft aged. When the old OP-20 budgets failed to accurately predict the correct Cost Per Hour for aircraft, the usual practice was for commands to seek additional funding through the "Mid-Year Review" process, where claimants request additional funding during March of each fiscal year. Eventually, moving averages were eliminated altogether in favor of the most recent historical cost data. However, as budgets became tighter during the 1990s, less money was available at mid-year reviews, and the process of programming funds every two years (conducting the POM during even budget years) meant that OP-20 cost per hour based on the most recent historical data still lagged behind actual costs. [Ref. 58] The resulting funding shortfalls have typically resulted in "bow waves." A "bow wave" is a funding shortage caused by deferred maintenance shifted into the next fiscal year to keep a unit operating. This practice has the effect of compounding over multiple years if the OP-20 continues to fail to predict costs and additional funds are not appropriated to pay off the "bow wave."

2. Peace Dividend Raiding of O&M Dollars

Congressional and Department of Defense analysts, searching for efficiencies in the defense budget have adopted the frequent practice of forcing efficiency savings on claimants by factoring a "negative budget wedge" into future budgets. A "negative budget wedge" is a projected savings through an improved process. Unfortunately, cost savings using this approach do not always materialize, and may result in additional funding shortfalls. In addition, an increase in unfunded contingency operations by U.S. forces in the 1990s often meant that the Department of Defense had to levy 'taxes' on the

military services to pay the operational bill. Worse, each service would simply have to rearrange insufficient funds within its own budgets to cover the operational expenses.

3. Aging Aircraft and Diminished Procurement Funding

During the 1980s the Department of Defense had large enough budgets to field multiple new types of aircraft. The limited wear on the aircraft plus manufacturers warranties on the equipment meant that maintenance costs were lower. However, as aircraft began to age in the 1990s, and older aircraft from the 1960s and 1970s continued to be used, the cost of maintaining the aircraft increased. In addition, procurement funding for new replacement aircraft was significantly reduced to fund current operations, or to achieve budget savings. The result is increased Aviation Fleet and Depot Level maintenance costs for parts reaching the end of their service life. An example of this is reflected in Figure 3.8 from the 1997 NCCA study which showed an increase in parts that were declared Beyond the Capability of Maintenance (BCM). This means that a broken part is either unrepairable at an organizational or intermediate maintenance level, or is too costly to repair. In either case, it must be bought with the risk that the cost of the part has escalated as well.

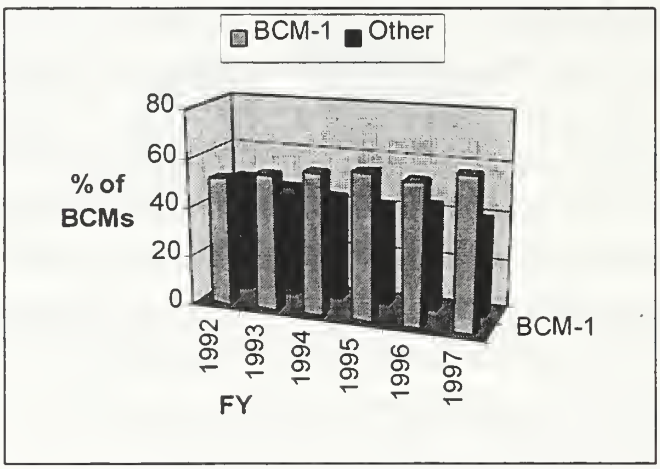


Figure 3.8. Increase in Overall Parts which are BCM-1 (Beyond Capability of Maintenance—Repair Not Authorized)[Ref. 59]

4. Failure of Equipment to Meet Life-Cycle Goals

In the annual formulation of AFM and Depot Level maintenance costs by N-889, program managers from the Naval Inventory Control Point (NAVICP, Mechanicsburg, Pennslyvania) produce engineering cost estimates to predict a given number of each major type of part that will fail during the coming year. Often times the NAVICP engineers failed to accurately predict the Mean Time Between Failure of a particular part,

or the number of broken parts in a particular year. As a result, the cost of many parts continued to rise, driving up AFM and Depot level costs. Arkley discussed how the General Electric F-404 engine for the F-18 failed to reach its original estimated life cycle and thus significantly raised intermediate maintenance costs. [Ref. 60] Another example of an unforeseen maintenance difficulty were large quantities of sub-standard jet fuel that caused AV-8B Harrier turbo-fans to become pitted, requiring premature replacement. Some of these problems are preventable, while some are unforeseeable. In either case, the cost of maintenance can increase significantly beyond predictions.

5. Problems with Navy Working Capital Funds

The costs of Navy Working Capital Funds, incorporated into the OP-20 budget since 1986, began to skyrocket as NAVSUP (Commander, Naval Supply) began to have problems generating enough cashflow to remain legally solvent. As a result, the cost of overhead applied to aviation parts and depot level services rose. Analysts are technically correct in claiming that this increased cost should not affect aviation readiness because it is factored into OP-20 pricing at the beginning of the Fiscal Year. However, only enough funds to cover the engineering estimate of parts expected to fail is factored into the formula. Therefore, if an expensive part fails more often than predicted, the end result is the loss of Flying Hour Program funding to pay higher surcharges. [Ref. 61]

6. Operational Tempo

Despite the end of the Cold War and success in the Persian Gulf, the operational tempo for Navy and Marine Corps aircraft has remained high. The result is increased aircraft wear, and difficulty in maintaining manning levels necessary to keep aircraft flying. Personnel cut as part of the defense drawdown reduced the number of Marines available to maintain aircraft. The end result is higher maintenance costs, less efficiency, and increased cannibalization to keep aircraft flying.

The cumulative effect of all these problems has meant that by 1995, Marine Aviation units had difficulty keeping their primary authorized number of aircraft flying. The effects of not having the correct number of aircraft flying resulted in an under-execution of flying hours, which caused the OP-20 budget formula for Marine units to be underexecuted. The effect of underexecuting the OP-20 is that Marine squadrons risk not receiving the full amount of maintenance funding needed to maintain their aircraft. Reduction in executed flight hours resulted in Marine Aircraft Wings having the choice of either underexecuting hours and not receiving the money that they needed to repair aircraft, or overflying the aircraft that were in ready condition, causing a continually increasing backlog of maintenance difficulties and an ever increasing spiral of deadlined

aircraft. Within MARFORLANT specifically within 2nd MAW, the number of hours flown continued to decline and aircraft accumulated more maintenance discrepancies, causing unsafe conditions. In 1996, the CG of 2nd MAW, Major General Ryan, stopped trying to attain Flying Hour Program goals for safety reasons. [Ref. 62] Figure 3.9 shows the Flight Hour Execution Rate at 2nd MAW during the past five years and illustrates the increasing program costs with a significantly decreased PMR beginning in 1996.

FY	TOTAL HRS	CPH	FHP	NON-FHP	PMR
1994	128,899	2,217	$287M	$13.3M	83%
1995	136,408	2,384	$331M	$18.3M	84%
1996	121,795	2,531	$317M	$16.8M	79%
1997	97,893	2,880	$282M	$13.4M	59%
1998	100,582	3,600	$366M	$12.6M	71%

Figure 3.9. Historical FHP Execution Data at 2nd MAW

E. THE MARINE AVIATION CAMPAIGN PLAN

Before the AMSR working group met, Marine Corps leaders saw that the readiness death spiral had to be halted. "The Marine Corps recognized that in order to maintain and fly their given fleet of aged aircraft some fundamental changes to the way the aircraft were being flown and maintained must be done. With this in mind the Marine Corps adopted the Marine Aviation Campaign Plan" [Ref. 63]. The MACP "was specifically designed to maximize aviation combat readiness and increase the overall combat capability of Marine Aviation." [Ref. 64] In the words of General Terrence Dake, who was the Marine Chief of Staff for Aviation Plans and Policy during the adoption of the MACP, the status quo was "no longer an option." [Ref. 65] By stating the problems facing Marine Aviation as part of fiscal, manpower, and logistical requirements, the Marine Corps hoped to better use and allocate its resources, and to improve readiness at the tactical unit level. (Wing, Group, Squadron)

In broad terms, this attempt at improving the way Marine Aviation achieved readiness was to be accomplished through the preservation of Marine Corps assets (equipment AND personnel), reduction of overall operational tempo, and a balancing of

resources against requirements. Figure 3.10 shows the revised MACP divided into six major categories with their associated goals.

A survey of the MACP shows that nearly every goal affects the Marine Corps Flying Hour Program. From the perspective of the MARFORLANT Aviation Budget Officer, the changes for the Flying Hour Program were a drastic departure from the unwritten standards of the FHP. Commanders at tactical unit levels would no longer try to plan operations by trying to accommodate FHP flight hour goals. They would plan by sortie instead of flight hour, with the philosophy that a decrease in hours flown with an increased emphasis on the quality of flight training would not decrease overall readiness. This deemphasis of the pursuit of a flying hour goal would simplify the operational planning process, maintain a ready force, and preserve aircraft assets. Finally, in an agreement with USMC Aviation Plans and Policies, the projected savings from reduced flight time would be reprogrammed into the acquisition of more and better simulators to supplement the loss in actual flight hours.

Topic	Category	*Goal*
1. Aviation Manning	Enlisted Manning	*1. Man Units at 90% of T/O* *2. Increase "Top Six" Structure (E4-E9) from 64% to 70% of Aviation Enlisted Force*
	Officer Manning	*1. Pilot Resignations<40 Year*
2. Naval Aviator Time to Train		*1. Undergraduate "Pool" Time not to Exceed 3 Months* *2. FRS "Pool" Time not to exceed 2 months* *3. FRS Time-to-Train w/in 10% of Programmed Time* *4. Aviator Street-to-Fleet w/in 10% of Programmed Time*
3. Flying Hour Program		*1. Avg Minimum of 12-15 Sorties/Month/Aircrew* *2. Execute Flying Hour Program within 2% of Sortie Based Projections*

Figure 3.10. Summary of the Marine Aviation Campaign Plan

4. Simulators		1. *Program and Fund a Simulator Master Plan with FHP savings* 2. *Increase Simulator Usage per Training and Readiness Manuals with a CRP (Combat Readiness Percentage) Credit*
5. Operations, Training, and Readiness	Training and Readiness Program	1. *Revise T & R goals to focus on unit core competencies rather than high-risk missions* 2. *Maintain minimum Squadron Core Capability per T & R Manual*
	Training and Exercise Employment Plan (TEEP)	1. *Execute planned TEEP rather than changing schedules on short notice* 2. *Integrate MCTEEP at Battalion/Squadron level to get a true reflection of OPTEMPO.*
	OPTEMPO Management	1. *Carefully factor in more planned operational pauses.* 2. *Aircraft Utilization Rates should be less than Weapons System Planning Document rates.* 3. *No loss of annual leave for Marines.*
	Operational Risk Management	1. *Implement a new Risk Management Process to help improve risk vs. benefit analysis.*
	Readiness Reporting	1. *Revise SORTS Order*

Figure 3.10 (Continued)

6. Aircraft Material Condition	1. *Deployed Squadrons have 100% of Primary Authorized Aircraft* 2. *Meet or Exceed 73%/56% for MC/FMC Rates* 3. *Complete SDLM cycles within 10% of Programmed Time* 4. *10% Increase in Man-Hours Dedicated to Treating & Preventing Corrosion*

Figure 3.10 (Continued)

F. SUMMARY

This chapter described the organizational context and problems that concern the MARFORLANT Aviation Budget Officer. It provides the information necessary to understand aviation finance at MARFORLANT, and provides the background necessary for the quantitative and qualitative analysis that will follow in the next two chapters.

IV. RESEARCH METHODOLOGY AND PRESENTATION OF DATA

A. INTRODUCTION

The purpose of Chapter IV is to describe the methodology used to analyze the Flying Hour Program at MARFORLANT and to present the quantitative cost data collected from AIRLANT, MARFORLANT, and 2nd MAW archives. The research methodology section of the chapter focuses on a brief review of linear regression techniques. The presentation of data section discusses how the cost information was adjusted prior to analysis. Sample spreadsheets present excerpts of the collected cost data. However, because of the size of the database, spreadsheets with all the cost data used in the analysis are contained in Appendix B.

B. COST ESTIMATION USING PARAMETRIC ANALYSIS

Arkley described three main quantitative methods that are commonly used for cost prediction in business and government: the analogy method, the engineering method, and the parametric method. The analogy method compares relationships from a known system and transfers them to a previously unanalyzed system. Analogous cost estimates are prepared by identifying key characteristics from known systems and comparing them to similar characteristics of newer systems. This method can be useful when there is little data to generate estimates about a new system of relationships. However, the method is also dependent on the relationships between the two systems remaining constant in the future, which is rare in any dynamic environment. [Ref. 66]

The engineering method is a more comprehensive cost estimating technique, "based on an extensive knowledge of all the component costs and relationships affecting the total or final system cost. This method relies exclusively on definitive knowledge of all factors affecting cost, their relationships and their magnitudes. It is built on the assumption that future data relationships and their effect on cost are predictable and quantifiable from historical data on the components." [Ref. 67] This method is frequently used in attempting to build cost estimates for parts and sub-components of equipment, but is often too costly and time consuming for programs as large as the FHP.

"Parametric methods, such as regression analysis, "seek to define in mathematical terms all or part of the cause-and-effect relationships between two or more characteristics." This mathematical formula is usually based on deriving a trendline which best represents the overall relationship between a series of data points between independent and dependent variables within a relevant range. The formula from the derived line can

then represent the relationship in a future forecast, especially when the forecast is interpolated within the already established range of the analysis. [Ref. 68]

Like the analogy and engineering method, a basic assumption of a forecast using parametric methods is that the basic relationship between variables will not change in the future. Of the three methods surveyed the parametric method best fits the analysis of a complex program such as the FHP, because it can usually produce a good estimate of the future with reasonable accuracy and timeliness. The analogy method is not suitable because the Flying Hour Program already has extensive data from which to conduct analyses. Likewise, the engineering method may be more precise, but is still dependent on engineering estimates of the "mean time between failure" (MTBF) of thousands of aviation components. Therefore the engineering method is more likely to produce an unworkable or unwieldy model for a dynamic program such as the FHP. For this reason, this thesis uses parametric analysis as the primary method for understanding MARFORLANT FHP cost behavior.

1. Fundamentals of Linear Regression

As stated in Chapter II, the Flying Hour Program has been analyzed repeatedly using parametric methods in an attempt to understand its cost behavior, and to validate assumptions about the relationship between flight hours and program costs. In this thesis, regression and correlation analysis are the primary parametric techniques used to deduce whether aviation cost behavior at MARFORLANT is consistent with previous research already conducted by Byrne, Arkley, and NCCA.

Regression can be used to define linear, curvilinear, exponential or logarithmic relationships. A scatter diagram of data points plotted between one or more independent variables (X) and a dependent variable (Y) usually represents these relationships. Often times the difficulty of the analysis lies in the transformation of the data into a representative linear relationship. However, when this is successfully accomplished, the regression line "expresses the best average relationship between the dependent variable and independent variable to a series of observations...so that the line lies at the center of the range of observations." This thesis uses the most common method of deriving the regression line: the least squares method. The least squares method determines the values of the slope and the y-intercept of the line, so that the sum of the squared deviations between the observations and the fitted line is less than that from any other straight line that could be fitted through the observations. [Ref. 69] In this thesis, the independent variable (**X**) is most frequently the number of flight hours, while the dependent variable is the expected value of the formula ($\mathbf{Y}_c$), which is most often one of the flying hour cost pools. In its

most commonly used form, this function can be expressed as part of an algebraic expression:

$$\mathbf{Y_e = a + bX}$$

The expected value of **Y** means that the dependent variable that can be forecasted from the regression equation is only the average of many possibilities based on the size of the random error (also called residuals) within the equation. This random error is generally called **e**. Therefore the "actual observed value of the dependent variable, $\mathbf{Y_a}$, may or may not be exactly the same as the expected average value expressed by the regression line." [Ref. 70] For example, if flight hours were used to predict total cost for some element of the FHP, the actual value of total cost would follow this form:

$$\textbf{Total Cost} = \textbf{Expected Total Cost} \pm \mathbf{e = a + b(Flight\ Hours) + e}$$

In other words, the actual total cost achieved through the regression forecast is equal to the expected total cost ($\mathbf{Y_c}$) plus or minus the random error for the equation. The symbol "**a**" is equal to the value of the y intercept. The symbol "**b**" is the slope of the regression line.

When a regression line is derived using the least squares method, both Microsoft Excel and Minitab have several statistical outputs which help the researcher to understand the accuracy of the formula describing the relationship, and the strength of that relationship. Together these describe the "statistical significance" and "goodness of fit" of the regression line. In addition, there are several statistics and analytical tests that help determine whether the data has correctly met the assumptions inherent to proper regression analysis. Figure 4.1 is a sample output from MINITAB to help describe these statistics.

```
The regression equation is
TOTAL COST = 712505 + 1608 HOURS

Predictor          Coef         St Dev       T           P
Constant           712505       175720       4.05        0.000
HOURS              1607.5       212.7        7.56        0.000

S = 629536         R-Sq = 37.8%       R-Sq(adj) = 37.1%

Analysis of Variance
Source        DF          SS             MS           F      P
Regression    1    2.26300E+13 2.26300E+13         57.1   0.000
Residual Er   94   3.72536E+13 3.96315E+11
 Lack of Fit  92   3.67743E+13 3.99721E+11         1.67   0.449
 Pure Error    2   4.79305E+11 2.39653E+11
Total         95   5.98837E+13

92 rows with no replicates

Unusual Observations

Obs    HOURS TOTAL COST  Fit      StDev Fit Residual St. Resid
17     1474  2804501     3081999 163197     -277498     -0.46X
27      864  3754692     2101408 67367      1653285      2.64R
```

Figure 4.1. Sample Regression Results from MINITAB

Included in Figure 4.1 are most of the key statistics that help the analyst to determine both the nature of the relationship between the two variables and the strength of that relationship. At the top, the regression equation is listed, substituting X and Y for the names of the independent and dependent variables. The coefficients for both the y-intercept or **a** ($712505) and the slope or **b** (1608 * Hours) are listed.

These coefficients are accompanied by statistics that describe the goodness of fit of the regression: the standard error of the estimate or S, and the coefficient of determination or R^2. The standard error of the estimate, S_e, is the square root of the sum of the squared differences between the estimated Y value represented by the regression line and the observed value, $(Y_a - Y_c)$, divided by the number of degrees of freedom. The equation is shown below:

$$S_e = \sqrt{\frac{\Sigma(Y_a - Y_c)^2}{(n-2)}}$$

"The standard error is a measurement of the typical vertical distance from the sample data points to the regression line. If the error terms are normally distributed around the regression line, the standard error of the estimate can be used to examine the dispersion of data points around the regression line and assess the goodness of fit of the model." [Ref. 71]

The R^2 and adjusted R^2 statistics also help determine goodness of fit by examining the strength of the regression relationship. In this case, the strength of the relationship is determined by correlation analysis of the X and Y variables. The square root of R, (or simply R) is the coefficient of correlation and "and provides a relative measure of the relationship between the dependent variable and the independent variable. If there is a perfect relationship between the dependent variable and the independent variable, no error term exists and the standard error of the estimate would be 0, i.e., $S_e = 0$." [Ref. 72] Likewise a regression describing no relationship would be a straight line meaning $S_e = 1$. However, this description of a perfect versus imperfect relationship is counter intuitive. Therefore, the value S_e is subtracted from one to produce R. ($1-S_e = R$) When R=1, the regression line traces through the center of each data point on a scatter diagram. In addition, the R-value can be positive, signifying a direct relationship between X and Y, or negative, signifying an inverse relationship. (This is also found by looking at the sign of the slope of the line). While R represents the correlation between the X and Y variables, R^2 represents the percentage of the sample variation from the mean of the dependent variable that can be explained by the change in the independent variable for the data relationship being analyzed. [Ref. 73] In Figure 4.1, the R^2 is 37.8%. This means that approximately 38% of the relationship between TOTAL COST and FLIGHT HOURS can be explained by the regression equation. Conversely this also means that 62% of the relationship between TOTAL COST and FLIGHT HOURS is unexplained. As a result, the regression equation in Figure 4.1 would likely produce inaccurate results if used in forecasting. Often times regression is performed with data sets that are too small to eliminate the possibility that what is observed in the statistics is just a random occurrence. The Adjusted R^2 statistic compensates for this by recomputing the R^2 to account for the number of degrees of freedom in the data set. In many cases of the analysis performed on AIRLANT cost data within the thesis, the number of observations are frequently less than or equal to n=7. In these cases the Adjusted R^2 is presented rather than R^2.

Sometimes the R^2 or Adjusted R^2 statistics produce ambiguous results. For example, in Figure 4.1 an analyst most likely would be unsure whether the R^2 of 38% was statistically significant or not. In practical terms this is like asking the cliché question, "Is

the glass half empty or half full?" To answer this, several statistical measures can be used to interpret the relationship. These measures also use probability and relative measures of the standard deviation to show statistical significance. Thus, the analysis results are significant when these measures show that the results were most likey not a random occurrence. Three measures displayed in Figure 4.1 can be used to deter-mine the statistical significance of the regression line: the t-ratio, the F-ratio, and the p-value.

The t-ratio (T) helps determine "if the value of the slope, **b**, is significantly different from zero." [Ref. 74] In addition, it is used to judge whether the constant at the y-intercept, **a**, is also statistically significant as part of the equation. T-ratio is determined by dividing the "coefficient" by the "standard deviation" for the slope or constant being analyzed. "A high t-value indicates that the independent variable is important in explaining the value of the dependent variable. Generally, t-values of greater than two are desired except when the sample size is small, which requires higher t-values." [Ref. 75]

The F-ratio also helps to determine the statistical significance of the regression line. More importantly, it can also aid in determining whether a low R^2, such as the percentage in Figure 4.1, is significant. In the example, the F-ratio by its larger number (57.10) shows that the slope of the line and the R^2 are statistically significant and not just the result of a random deviation.

Finally, the p-value also can be used instead of the t-ratio or F-ratio to answer the question of statistical significance. The p-value represents the statistical probability that the results shown for a particular statistic are simple a random occurrence. In the case of the t-ratio, it's the probability that the regression results are just a random deviation from the null hypothesis that the slope of the equation is zero. In this thesis all null hypotheses will be analyzed using a 95% confidence level. Therefore, the α (the alpha), or chance that the results are a random occurrence will be .05. When interpreting the p-value in regression results, a p-value of less than .05, is interpreted by stating that there is less than five percent probability that the statistic is just a random deviation from the null hypothesis. Therefore, when the p-value is less than .05 we may reject the null hypothesis that the slope of the line is zero or the constant is merely a random occurrence.

Together, these statistics along with the analyst's judgment, help determine whether a regression model is useful for explaining the relationship or for future forecasting. Before making a final conclusion about a regression line, however, the analyst must still determine whether the data correctly fulfill the assumptions of regression analysis. This is one problem commonly seen today with regression analysis, especially

because this statistical tool is so widely available. When conducted properly, regression analysis should fulfill five basic assumptions:

- Linearity
- Normality of Error Distribution
- Constant Variance (Homoscedasticity)
- Zero Expected Value of Errors
- Independence of Error Terms

Linearity is the assumption that the dependent variable is linearly related to the independent variable. Although regression can be conducted for non-linear relationships, the manipulation of non-linear data into linear form increases the complexity of the model and the ease with which the relationship can be used to explain and forecast reality. This assumption can be checked by plotting X versus Y on a scatter diagram for each relationship and by using MINITAB's Pure Error Lack of Fit Test or the Experimental Lack of Fit Test to determine the possibility that there is a possible curvature in the data.

Normality of error distribution implies that the distribution of error terms (residuals) for each value of Y around each value of X fits a normal distribution. Absence of normality of error would be an indicator that the error terms are the result of a specific outside factor, which has not been considered in the model. If the error terms are not random within a normal distribution, the regression may be inaccurate because of averages that skew the data from its actual relationship. This assumption can be checked by using techniques for residual analysis. [Ref. 76]

Constant variance or ***homoscedasticity*** means that in addition to a normal distribution of errors, the variation of errors is also constant for all values of X, meaning that Y varies the same for a high input value or X or a low input value of X. This is important to rule out the possibility that there is a relationship between the variables that is being overlooked. In addition, a lack of constant variance can mean that the forecast is suspect at one or both ends of the relevant range of X data. Again, this assumption can be tested through residual analysis. [Ref. 77]

Finally, ***independence of error terms*** means that the residuals from the regression are independent from each other. "This means that each error term value is independent

of those values coming before and after it. In technical terminology, when this assumption is violated, it is said that serial correlation (or autocorrelation) exists among successive residual values. This assumption is most commonly violated when observations are drawn periodically over time." [Ref. 78] The Durbin-Watson test can be conducted to test for first-order autocorrelation. This test is "a summary measure of the amount of serial correlation in the error terms. With uncorrelated errors, the Durbin-Watson statistic takes on values near 2. If the errors are perfectly and positively correlated, the D-W statistic will be 0." [Ref. 79] The D-W statistic needs to be carefully interpreted since it has a range where the statistic is inconclusive.

Residual analysis is an important analytical step that must be conducted before the regression results are presented and interpreted. An explanation of specific techniques for analyzing residuals is not presented in this thesis. However, the techniques used for residual analysis include residual vs. fit plots (where the residuals (e) are plotted against the expected values of Y) and residual vs. explanatory variable plots (where residuals are plotted against the explanatory variable(s) (X)) in order to determine the source of a possible violation of assumptions. [Ref. 80]

2. Time-Series Analysis and Lagged Regression

One of the problems with analyzing cost data in the Flying Hour Program is that there is a tendency for the data to be auto-correlated when it is collected monthly, annually, or yearly. If the effects of the autocorrelated data are not recognized, these relationships of time can violate the regression assumption of serial independence. The effect of unanalyzed autocorrelation on the dependent variable can be a time lag in which the data acts "sticky" (i.e., dependent variable does not immediately respond to changes in the independent variable), because it was "relevant in explaining the behavior of the dependent variable but was ignored in a regression equation." [Ref. 81] Therefore, the analyst should be aware of the possible ways to account for the effects of time in his analysis, and know how to identify the true relationship between the variables. In this thesis two techniques which recognize the effect of time on data are used. The first is time-series analysis, which is used in a limited fashion in order to adjust data and make comparisons with other analyses. The second is lagged regression, which is used to search for time lags in the relationship between flight hours, and the recording of maintenance costs.

A time-series is, "a set of numerical data that is obtained at regular periods of time." [Ref. 82] In effect, all the data presented in this thesis can be presented in a time series. Understanding basic time-series techniques allows the adjustment of FHP data so

that the true relationship of the cost data is accurately defined. Data presented in a time-series can be analyzed strictly in relation to time as the independent variable by substituting the unit of time with an ordinal numbering sequence (i.e., Jan 1995=1, Feb 1995=2, Mar 1995=3, etc.). Like regression of random variables, a linear or non-linear relationship can be established using several methods, including the least squares regression method. Ideally, once time trends are removed from the data and a regression line is fitted, the trendline should represent the true nature of the relationship.

The classical decomposition time-series model seeks to isolate four different component factors within time-series data. These factors are trends, seasonality, cycles, and irregular variations. Trends are persistent long-term upward or downward patterns of movement, such as the tendency for the flying hour program to increase in cost despite fewer hours and lower inflation rates. Seasonality is a periodic, regular fluctuation of the data in the same way over time. Cyclical data is repeated up and down swings of data that does not necessarily follow a particular time cycle, such as economic fluctuations over time. Irregular fluctuations are unpredictable and nonrepeating variations in the data once trends, seasonality, and cycles have been removed.

Other time series models process time-series data in different ways. For example, moving averages or exponential smoothing are often used to replace data with cycles and fluctuation with a more constant trendline. This seems to be precisely the technique that the Special Assistant to the Flying Hour Program formerly used in trying to build the correct Cost Per Hour into the OP-20 model.

Lagged regression is a technique that attempts to explain a delay in the outcome of the dependent variable after the occurrence of the independent variable. The result is that the dependent variable data is adjusted in time to align it with the correct value of the explanatory variable. [Ref. 83] Arkley cited this type of relationship in his analysis of Intermediate Level and Depot Level Maintenance cost data. He noted lagged relationships between hours flown by the aircraft and the repair of major components that had to be shipped to another location or required a long period of time to repair. This thesis looks for similar tendencies in MARFORLANT cost data. Another example might be the time lag caused by administrative delays in data entry, although most units have internal control measures which would prevent these from being recorded more than one or two months after a maintenance action's occurrence. To uncover lagged relationships in this thesis, monthly cost data is lagged up to 6 months from the date of execution of the flight hours. Annual data may also be lagged by one year in order to uncover more accurate trendlines.

These are the essential concepts behind the parametric analysis that is conducted in this thesis. The next section describes the actual quantitative methodology used in the thesis.

C. QUANTITATIVE RESEARCH METHODOLOGY

Chapter I stated that one of the ways to answer the primary research question for this thesis was to analyze MARFORLANT FHP cost data in comparison with several benchmarks from previous research. The benchmarks relevant to quantitative analysis are summarized below.

1. Fuel costs showed some correlation to flight hours, but 25 to 75 percent of the relationship between the two variables was unexplained. (Byrne)

2. Fuel and OMA costs fit significantly when analyzing the variable relationship between flight hours and these cost pools. (Arkley)

3. Fuel costs showed a variable relationship with flight hours, consumables showed a fixed plus variable relationship, while AVDLR costs did not show any significant relationship to number of hours and was modeled as a fixed cost. (NCCA)

4. Maintenance costs for parts showed no correlation to flight hours, and was assumed to be a fixed cost of operations. (Byrne)

5. IMA costs often show less statistical significance when regressed versus flight hours because of maintenance time lags and work that can be repaired by other commands at other locations. (Arkley)

6. DLR cost can show strong statistical significance, if data is adjusted properly. (Arkley)

7. Regression analysis can yield a statistically significant relationship which reflects total cost vs. flight hours at the Department of the Navy level. (NCCA)

8. Comparisons of NCCA model versus OP-20 POM predictions for budget outyears showed that the Department of the Navy was underestimating the future cost of the program. (NCCA)

These benchmarks were combined to build a set of five hypotheses for MARFORLANT cost data. Regression analysis is used to gather evidence that supports or rejects these hypotheses.

An important fact to be remembered about regression is that correlation is not causation, and outcomes containing a high correlation and statistical significance do not necessarily prove a hypothesis. Therefore, analysts commonly create a corollary to the research hypothesis stating that there is no relationship between an independent and dependent variable. This is called a null hypothesis. When properly conducted, regression analysis allows us to accept or reject a null hypothesis. For example: although, an analyst might believe that fuel costs vary directly with flight hours, the correct null hypothesis in response to this belief is that "there is no relationship between fuel cost and flight hours." If the analysis shows results with a p-value of less than .05, the analyst can only correctly state that there is sufficient evidence to reject the null hypothesis. In other words, the analyst is more than 95% confident that the null hypothesis is false. Using this method, the five research hypotheses all have corresponding null hypotheses. The intent of the regression analysis is to search for evidence that allows us to reject the null hypothesis. These results, combined with qualitative evidence about MARFORLANT cost data, should allow us to draw conclusions in support of the research questions. The five hypotheses are presented below, with each corresponding null hypothesis.

a. Fuel Costs

H.1. Fuel costs for MARFORLANT FHP cost data vary directly to flight hours and will show a high coefficient of determination, when analyzed both at the aggregate level and at the T/M/S level.

H.2. ***Null Hypothesis***: Fuel costs show no relationship to Flight Hours.

b. Flight Equipment Costs

H.3. Flight Equipment (OFC-01 Code 7F) costs for MARFORLANT FHP are fixed and show no relationship to flight hours.

H.4. ***Null Hypothesis***: Flight Equipment costs show no relationship to Flight Hours.

c. Organizational and Intermediate Maintenance Costs (MNT)

H.5. Organizational and Intermediate Maintenance costs at MARFORLANT FHP cost data vary directly to flight hours with an additional fixed price component.

H.6. ***Null Hypothesis***: Maintenance costs shows no relationship to Flight Hours.

d. Aviation Depot Level Repairable Costs (DLR)

H.7. Aviation Depot Level Repairable costs are a fixed cost and show no correlation to flight hours.

H.8. ***Null Hypothesis***: Maintenance costs shows no relationship to Flight Hours.

e. Total FHP Costs

H.9. Flight Hour Program Total Costs have a fixed plus variable cost structure in relation to flight hours.

H.10. ***Null Hypothesis***: Flight Hour Program Total costs show no relationship to Flight Hours.

The testing of these hypotheses was conducted at two levels where cost data relevant to MARFORLANT were available. The first level of analysis was conducted on cost data found in AIRLANT's Flying Hour Cost Reports that show actual year end figures on the quantity of hours flown and costs within the Fuel, Maintenance and Aviation Depot Level Repairables cost pools. AIRLANT reconciles these annual reports with the Defense Finance Accounting Service, and conveniently categorizes them in an OP-20 format with aggregate data by service, T/M/S, and major Flying Hour Program category. AIRLANT annual cost data analyzed included aggregates by AIRLANT, by Marine TACAIR, by Marine Fleet Air Training, and by the F/A-18, AV-8B, CH-46E, and CH-53E aircrafts. Although the cost reports are published by AIRLANT, they seemed to be the best and simplest source of cost data available which

could reveal aggregate trends in the most important MARFORLANT categories. None of the aggregate data are compiled into a MARFORLANT comprehensive cost pool because it would only mask the true behavior of each category, and still gives the best understanding of the aggregate trends of the most significant MARFORLANT FHP costs. In addition to providing information about the historical trends and financial condition of the Flying Hour Program at MARFORLANT, this level of analysis is similar to the type of data analyzed by NCCA.

Since both Arkley and Byrne conducted FHP cost analysis at the aircraft type level, a second level of analysis was conducted by aircraft type on 2nd MAW cost data. Arkley's F-18 data showed a high degree of correlation and statistical significance in comparison to Byrne's analysis, and that of NCCA. To explore the possibility that this may have occurred because aggregate data masks the true nature of individual aircraft cost behavior, the analysis was conducted on information pulled directly from a 2nd MAW cost database named DOLARS. DOLARS is a local database designed by a former Marine turned analyst using Microsoft FOXPRO. DOLARS collects monthly data through unit Budget OPTAR Reports (BOR reports), that are one of the principal reporting mechanisms through which FHP data is collected and eventually reported up the entire budgeting chain of command. Rather than reanalyzing annual data from 2nd MAW that is inherent in the AIRLANT Flying Hour Cost Reports, DOLARS allows a collection of monthly cost data closer to its source. Three types of aircraft were selected at 2nd MAW for regression analysis using methods similar to Arkley. The F/A-18A, F/A-18C, and F/A-18D were selected to facilitate a direct comparison with Arkley's analysis of Navy and Marine Corps Reserve F/A-18s. In addition, the AV-8B Harrier II, and the CH-46E Sea Knight helicopter were selected for comparison of cost behavior with the F/A-18. The Harrier II was selected because it is the only other tactical attack fixed wing aircraft in the Marine Corps' current inventory. Also, the fuel required using Vertical/ Short Take Off and Landing capability might provide an interesting comparison of fuel costs with the F-18. The CH-46E was chosen not only because it is a helicopter, but also because it is near the end of its service life and might provide interesting results in the Maintenance and DLR cost pools.

Regardless of the outcome of the quantitative analysis performed on these data, the results should help to answer the research question: "What are the historical trends of flying hour program budgeting and execution at MARFORLANT?" In addition, it should add insight to the research questions about MARFORLANT budgeting

dynamics, and future budgeting adjustments needed in order to successfully meet the goals of the MACP.

D. QUALITATIVE RESEARCH METHODOLOGY

The primary research question of this thesis is still qualitative. How should the Flying Hour Program at MARFORLANT be managed to maximize its value to Marine Aviation? Many ideas implicit in the answer have already been discussed through Chapters II and III. However complex the budgeting and execution process seems, or how well the statistical results of the regression are presented, the Flying Hour Program manager still must decide the best way to manage the FHP at his level without jeopardizing the operational and logistical health of the Marine Aviation. To answer that question and also the remaining secondary research questions of the thesis, archival research was conducted by collecting documents and conducting interviews with key personnel involved with the FHP at 2nd MAW, MARFORLANT, and AIRLANT.

The unique methodology of this thesis is that these data will be presented in terms of Simons' Levers of Control, presented in Chapter II. The intent of using Simons' model is to recognize the inherent tensions of conflicting priorities and processes in the FHP, and to understand how they should be balanced.

E. PRESENTATION OF QUANTITATIVE DATA

1. AIRLANT Flying Hour Cost Reports

The AIRLANT Flying Hour Cost Report models N-88's OP-20 format for the reporting of annual FHP cost data. Costs are broken down by Program Element and Program Element Number such as TACAIR (Navy or Marine) by totals of all aircraft within the category or TACAIR by individual Type/Model/Series. A typical cost reporting line includes the same categories reviewed for the OP-20 in Chapter II such as Forces (# of aircraft in the category), Hours, Cost Per Hour Categories (Fuel, AVDLR, Maintenance, Total), and Annual Cost Categories (Fuel, AVDLR, Maintenance, Total). In addition, AIRLANT prepares cost reports that include and exclude free fuel. Since deployed forces occasionally operate in contingency areas with fuel paid for by other nations.

Since Chapter II mentioned that cost does not always vary directly with the number of Flight Hours, the data extracted from these reports for analysis used only the annual cost categories. This aggregate cost data were entered into Microsoft EXCEL spreadsheets for analysis and sorted by type. Data from 1992 to 1998 are presented. Data prior to 1992 was not used because of the unusual costs of the Persian Gulf War and

the different budgeting dynamics in effect during the Cold War. Several examples of raw aggregate data presented prior to adjustment or analysis is presented in Figure 4.2. The entire data used in analysis from AIRLANT is in Appendix B.

2. 2nd MAW Cost Data

The 2nd MAW DOLARS is capable of producing complex arrangements of cost and flight hour data in a variety of forms. Data can be sorted by T/M/S, by FHP category, by squadron, group, or by the wing as a whole. In addition, data can be extracted for units on overseas deployment cycles. Flight Hour records can be compared with the budgeted flight hours, and can be sorted in a variety of ways as well. The advantage of this is the visibility 2nd MAW gains on local events and trends. However, because the data is broken down into so many categories, only cost and flight hour data from TACAIR and Fleet Replacement Squadron Aircraft for the types analyzed were compiled into a MICROSOFT EXCEL spreadsheet. Figure 4.3 presents a sample of cost data from this database. Again, the entire data used in analysis from AIRLANT is in Appendix B.

3. Adjustment of Cost Data

The regression analysis section of this chapter pointed out that data arranged in a time-series must be normalized to separate the true regression relationship from known cycles of time, which affect the data. For this thesis, there were three possible variations of data adjustment that could be used to normalize the data.

The first choice is to adjust all cost data by a simple general inflation index applied to all Department of the Navy Operations and Maintenance funds. This strategy would have the least amount of impact on the raw data and would strip out a long-term trend of very slow inflation of prices. The effect on the cost figures would be minimal, thus the relationships between cost pools and flight hours is still very similar to the data in its nominal form.

The second choice is to adjust each cost pool by its own more appropriate inflation index. Fuel costs would be adjusted by a fuel escalation index found in NAVCOMPT 7111 budget guidance. This index accounts for annual price changes in fuel costs, and has a much stronger effect on the fuel cost pool. The remaining categories of cost, Flight Equipment (in the case of 2nd MAW), Aviation Fleet Maintenance (MNT), and Aviation Depot Level Repairables would all still be adjusted by the Operations and Maintenance Cost Escalation Index also found in versions of NAVCOMPT 7111. This method would account for obvious differences in the price of fuel, while keeping the adjustment of maintenance costs simple and relatively similar to the data in raw form.

YEAR	TOTAL HOURS	TOTAL FUEL	TOTAL AFM	TOTAL AVDLR	TOTAL COST
1992	593099	$269.531	$293.966	$455.087	$1,018.584
1993	545837	$235.904	$294.273	$502.435	$1,032.612
1994	498344	$267.356	$254.009	$529.836	$1,051.201
1995	498344	$233.529	$284.962	$678.536	$1,197.027
1996	479171	$243.083	$294.651	$551.896	$1,089.630
1997	427110	$223.692	$288.295	$561.374	$1,073.361
1998	428330	$261.368	$323.007	$785.627	$1,370.002

AIRLANT Annual Flying Hour Program Cost Data (in millions of nominal $)

YEAR	TOTAL HOURS	TOTAL FUEL	TOTAL AFM	TOTAL AVDLR	TOTAL COST
1992	125,418	$53.159	$74.162	$101.471	$228.792
1993	113,587	$46.313	$68.017	$112.599	$226.929
1994	112,137	$58.492	$62.923	$128.637	$250.052
1995	120,021	$58.840	$79.041	$161.648	$299.529
1996	104,488	$55.464	$88.222	$135.217	$278.903
1997	80,983	$41.710	$75.990	$115.972	$233.672
1998	84,572	$47.857	$87.209	$177.485	$312.551

Marine TACAIR Annual Flying Hour Program Cost Data (in millions of nominal $)

YEAR	TOTAL HOURS	TOTAL FUEL	TOTAL AFM	TOTAL AVDLR	TOTAL COST
1992	17102	$7.320	$8.741	$9.005	$25.066
1993	16268	$6.705	$8.850	$15.047	$30.602
1994	16762	$8.469	$7.422	$14.932	$30.823
1995	16762	$6.697	$8.196	$16.874	$31.767
1996	17307	$6.970	$11.140	$18.040	$36.150
1997	16909	$5.981	$10.653	$19.905	$36.539
1998	16010	$6.328	$14.092	$27.201	$47.620

Marine Fleet Replacement Squadron Annual Flying Hour Program Cost Data
(in millions of nominal $)

YEAR	TOTAL HOURS	TOTAL FUEL	TOTAL AFM	TOTAL AVDLR	TOTAL COST
1992	21775	$10.989	$15.407	$14.644	$41.040
1993	17936	$8.725	$14.346	$26.086	$49.157
1994	16158	$8.932	$9.920	$24.140	$42.992
1995	17213	$8.356	$11.599	$28.926	$48.881
1996	14745	$7.850	$11.111	$24.877	$43.838
1997	10019	$5.081	$12.297	$25.604	$42.982
1998	9503	$5.722	$15.266	$32.638	$53.626

Marine AV-8B (TACAIR only) Annual Flying Hour Program Cost Data
(in millions of nominal $)

Figure 4.2. Aggregate Annual Cost Data from AIRLANT Flying Hour Cost Reports

MONTH	YEAR	TYPE	UNIT	TOT HRS	7B (FUEL)	7F (FLT E)	7L (AFM)	9S(DLR)
OCT	1993	AV-8B	MAG-14	1502	404377	17656	983726	1208841
NOV	1993	AV-8B	MAG-14	1587	1387808	20444	1065726	3993832
DEC	1993	AV-8B	MAG-14	1265	940714	23271	1038230	2011457
JAN	1994	AV-8B	MAG-14	1339	821546	34987	1123930	1857766
FEB	1994	AV-8B	MAG-14	1348	764488	18908	917451	2404178
MAR	1994	AV-8B	MAG-14	1766	1035192	15315	977172	3014189
APR	1994	AV-8B	MAG-14	1324	1257645	140	1667121	1775139
MAY	1994	AV-8B	MAG-14	1531	1282844	4018	900314	2067036
JUNE	1994	AV-8B	MAG-14	1550	802270	12887	1166062	2290773
JULY	1994	AV-8B	MAG-14	1675	1373295	7372	1315474	3028675
AUG	1994	AV-8B	MAG-14	1026	1143338	13976	640037	2012645
SEP	1994	AV-8B	MAG-14	496	683145	-7047	462133	3558266
OCT	1994	AV-8B	MAG-14	1561	731463	14870	1206108	3531929
NOV	1994	AV-8B	MAG-14	1216	923898	16474	987739	2109321
DEC	1994	AV-8B	MAG-14	1372	465518	18933	1008006	2261507
JAN	1995	AV-8B	MAG-14	1593	868581	23474	774113	3029540
FEB	1995	AV-8B	MAG-14	1391	1211281	14637	914386	3713828
MAR	1995	AV-8B	MAG-14	1601	745056	14604	1354621	2333020
APR	1995	AV-8B	MAG-14	1333	956798	4535	822491	2176167
MAY	1995	AV-8B	MAG-14	1518	100419	30839	1174005	2440097
JUNE	1995	AV-8B	MAG-14	1125	842855	5251	293291	2172306
JULY	1995	AV-8B	MAG-14	1345	999299	46697	1284104	1605842
AUG	1995	AV-8B	MAG-14	1010	893291	14789	909028	2257422
SEP	1995	AV-8B	MAG-14	1296	874066	42131	800951	1582533
OCT	1995	AV-8B	MAG-14	1650	741812	23514	972789	3414815
NOV	1995	AV-8B	MAG-14	1554	555970	6925	911972	1793780
DEC	1995	AV-8B	MAG-14	1822	981330	21635	791611	1333825
JAN	1996	AV-8B	MAG-14	1667	895739	15246	983082	2230832
FEB	1996	AV-8B	MAG-14	2115	933669	15782	854062	2761881
MAR	1996	AV-8B	MAG-14	1416	392216	6326	1196282	2442672
APR	1996	AV-8B	MAG-14	1464	867922	18769	1221727	2595214
MAY	1996	AV-8B	MAG-14	1423	1063056	13899	1309351	2246438
JUNE	1996	AV-8B	MAG-14	1423	1489109	26439	1449470	2195582
JULY	1996	AV-8B	MAG-14	1139	970480	10871	1038954	1983706
AUG	1996	AV-8B	MAG-14	1171	514532	49449	1012595	3228143
SEP	1996	AV-8B	MAG-14	994	300067	-1386	888471	1147881
OCT	1996	AV-8B	MAG-14	545	292287	26493	1071448	2818908
NOV	1996	AV-8B	MAG-14	540	219499	8573	870316	1918145
DEC	1996	AV-8B	MAG-14	534	410435	5564	759340	1723215
JAN	1997	AV-8B	MAG-14	1162	470013	10323	895926	2515425
FEB	1997	AV-8B	MAG-14	898	896546	15681	1313721	3625735
MAR	1997	AV-8B	MAG-14	1206	312922	5486	1306360	3936498
APR	1997	AV-8B	MAG-14	1135	645481	5030	984683	3411195
MAY	1997	AV-8B	MAG-14	1056	815032	13496	985694	1815020
JUNE	1997	AV-8B	MAG-14	843	318581	7859	951949	2185724
JULY	1997	AV-8B	MAG-14	1067	525445	12793	1037602	346127
AUG	1997	AV-8B	MAG-14	992	429274	7833	1063585	1133512
SEP	1997	AV-8B	MAG-14	715	816134	4707	822263	3391960

Figure 4.3. Monthly Cost Data by T/MS from 2nd MAW Database

The third choice for data adjustment is to adjust fuel by its NAVCOMPT 7111 index, Flight Equipment by its O&M Escalation Index, and Aviation Fleet Maintenance and Aviation Depot Level Repairables by an index called Variable Annual Demand. Variable Annual Demand (VAD) represents the annual price change of the Flying Hour Program. It accounts for annual average price changes in aviation consumables and repariables, changes in overhead rates charged by NAVSUP (surcharges), funds budgeted in excess of the N-88 OP-20 projections because of the annual change in those surcharges, and ordinary inflation adjustments such as the O&M Escalation Index. Using this method means that the adjustment of raw data is more severe in changing it from its original form. In particular, the creation of a VAD index is an "average of averages," [Ref. 84] meaning that it is a compilation of several different dynamic factors and may not adjust each cost category in the same way. However, it also captures known changes that effect the pricing of the FHP. To get the best test of the relationship and correlation between cost pools and flight hours, these factors need to be adjusted in the raw data. In addition, the adjustment is not as severe as Arkley's adjustment of AVDLR data for the life cycle changes of the F-18's F-404 engine. The design and effect of price changes, surcharges, and the VAD on the Flying Hour Program is a dynamic topic with enough complexity to warrant its own thesis.

The Secretary of the Navy Office of the Comptroller for Budgeting (FMB) annually publishes Budget Guidance with price escalation indices pre-computed. These indices help in the preparation of budget estimate submissions and programming by giving historical price and inflation changes for previous years, and projected price changes and inflation rates for future years. Multiple indices showing price changes in appropriation and cost categories are produced using different base years. A base year is the fiscal year that all other years will be compared to once an index is created. Therefore the base year is always 100% or 1.00, depending on how the analyst builds his spread-sheet.

Figure 4.4 shows the raw inflation rates for average fuel cost and its conversion to a percentage index using Fiscal Year 1998 as the base year:

Year	Fuel Inf Rate	% Index	Index/100
1992	-14.8	68.58	0.69
1993	9.6	75.17	0.75
1994	14.1	85.76	0.86
1995	-12.4	75.13	0.75
1996	5.6	79.34	0.79
1997	5.3	83.54	0.84
1998	19.7	100.00	1.00
1999	-8.8	91.20	0.91
2000	2.1	93.12	0.93
2001	2.1	95.07	0.95
2002	2.1	97.07	0.97
2003	2.1	99.11	0.99
2004	2.1	101.19	1.01
2005	2.1	103.31	1.03

Figure 4.4. Fuel Adjustment Index (Base Year 1998) [Ref. 85]

Since FY 1998 is the base year, it is automatically 100% or 1.00. The Fiscal Year 97 index is computed by dividing the current year percentage in the numerator by 1 + the inflation rate as a percentage of 1.00 in the denominator. This yields a percentage that can be converted to a usable index by dividing by 100. Two examples from the fuel index are listed below.

- FY 97 Index = {Current Year FY 98/(1 + 98 Inf Rate} = {100/(1+ .197)} = 83.54
- FY 96 Index = {Current Year FY 97/(1 + 97 Inf Rate) = {83.54/(1 + .053)} = 79.34

Conversely, when building an index in the future from a base year the current year index is multiplied by 1 + the projected next year inflation rate. Again, two examples from the fuel index are presented below.

- FY 99 Index = {Current Year FY 98 x (1 + FY 99 Inf Rate)} = {100 x (1 + (-.088))}= 91.20

- FY 00 Index = {Current Year FY 99 x (1 + FY 00 Inf Rate)} = {91.2 x (1 + .021)}= 93.12

Figure 4.5 shows an Operations and Maintenance Adjustment Index used for the Flight Equipment Cost Pool. [Ref. 86] Figure 4.6 shows the Index for Value of Annual Demand. [Ref. 87] Also included in the VAD Chart are the NAVSUP Navy Working Capital Fund surcharges for the years included. Both the VAD and Surcharge in their

original form are expressed as a percentage of overhead for $100 of direct cost. Therefore before converting the VAD to an index, it was converted to a total cost figure per $100 dollars of direct cost.

Year	O&M Inf Rate	% Index	Index/100
1992	2.6	89.32	0.89
1993	2.4	91.47	0.91
1994	2.0	93.30	0.93
1995	1.9	95.07	0.95
1996	1.9	96.88	0.97
1997	1.7	98.52	0.99
1998	1.5	100.00	1.00
1999	1.6	101.60	1.02
2000	1.6	103.23	1.03
2001	1.8	105.08	1.05
2002	1.8	106.98	1.07
2003	1.9	109.01	1.09
2004	2.2	111.41	1.11
2005	2.2	113.86	1.14

Figure 4.5. Operations and Maintenance Price Adjustment Index (Base Year 1998)

Year	Srchrge Chnge	VAD Chnge	Sample Price	VAD Ovrhd	Annual Price Change per $100	VAD Index %	Index 100
1995	56.6	28.3	100.00	28.3	128.30	94.00	0.94
1996	23.8	-21.6	100.00	6.70	106.70	78.00	0.78
1997	27.6	5.7	100.00	12.40	112.40	82.00	0.82
1998	55.7	24.7	100.00	37.10	137.10	100.00	1.00
1999	47.8	-3.6	100.00	33.50	133.50	97.00	0.97

Figure 4.6. VAD Price Adjustment Index (Base Year 1998)

A sample regression analysis using all three of the adjustment options was conducted on sample raw data. The third adjustment choice produced the best data improvement on sample regression formulas, therefore it was selected for use in normalizing all data. Raw data are adjusted in Microsoft EXCEL by divided each raw data cost figure by the (Index/100) figure for the appropriate year. This produces cost

data in FY 98 constant dollars. A comprehensive adjustment matrix is presented in Figure 4.7.

Year	Fuel	OM	VAD
1992	0.69	0.89	
1993	0.75	0.91	
1994	0.86	0.93	
1995	0.75	0.95	0.94
1996	0.79	0.97	0.78
1997	0.84	0.99	0.82
1998	1.00	1.00	1.00
1999	0.91	1.02	0.97
2000	0.93	1.03	
2001	0.95	1.05	
2002	0.97	1.07	
2003	0.99	1.09	
2004	1.01	1.11	
2005	1.03	1.14	

Figure 4.7. Data Adjustment Matrix

This concludes the methodology and data presentation chapter. The chapter provided basic parametric analysis techniques, including regression analysis and time-series analysis. The quantitative and qualitative research methodology of the thesis was then presented. This highlighted the use of the hypothesis and null hypothesis for regression analysis. Cost and Flight Hour data were analyzed at the aggregate level from AIRLANT cost reports, and by T/M/S from 2nd MAW. Finally, the methods to create inflation and price change indices were analyzed.

V. ANALYSIS

A. INTRODUCTION

This chapter presents the quantitative analysis of MARFORLANT cost data outlined in Chapter IV, followed by a qualitative analysis using Simons' levers of control as a framework for discussion. Together, these discussions allow the remaining secondary research questions to be discussed and provide supporting evidence to answer the primary research question of the thesis in Chapter VI.

B. REGRESSION RESULTS

The tables presented in this chapter and Appendix C display the regression results for the analysis of cost versus flight hour relationships in several different categories. Because the research methodology called for 95 percent confidence as the standard of statistical significance, only those results with a p-value equal to or less than .05 for both the b coefficient and F statistic were considered to be statistically significant. Several regression equations showed statistical significance in these areas, but lacked a strong coefficient of determination. In other words, these results correctly explained part of the relationship, but should not be used for forecasting because of the amount of variation that was unexplained by the variables. In addition, even if the slope of a regression line was statistically significant, the coefficient (y-intercept) must be statistically significant to be included in the equation as a fixed cost.

A sample results table is displayed in Figure 5.1:

AIRLANT Regression Results (FY 95-98) **(Intercepts in 1000s of $)**

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-33032	-0.76	0.52	0.6975	7.46	0.02	96.5%	94.8%	55.72	0.01	5843
AFM v. Hours	394498	1.36	0.31	-0.1202	-0.19	0.86	1.8%	0.5%	0.03	0.86	39474
DLR v. Hours	830318	2.19	0.16	-0.2237	-0.27	0.81	3.6%	0.4%	0.07	0.81	51677
Totl v. Hours	1191783	3.61	0.07	0.35	0.49	0.67	10.6%	0.3%	0.24	0.67	44967

Figure 5.1. Sample Regression Results Table

The **X v. Y** column shows the independent variable and the dependent variable used in each respective analysis. The **a** column represents the coefficient for the y-intercept of the regression line. This figure represents the intersection in 1000s of dollars. The **b** column represents the coefficient for the slope of the regression line. Both **a** and **b** are

followed by their respective T- ratio (**t**) and p-value (**p**) which help explain whether the coefficients are statistically significant. The $\mathbf{R^2}$ and **Adjusted** $\mathbf{R^2}$ are displayed to show the percentage of the functional relationship explained by the regression formula. The **F** statistic shows the overall statistical significance of the entire equation, and is useful particularly if the $\mathbf{R^2}$ and **Adjusted** $\mathbf{R^2}$ are low, but still have **p** values for their coefficients that are less than or equal to .05 (α). The p-value following the F statistic gives this assessment in probabilistic terms as well. Finally, the Standard Error of the Estimate is represented by **S**, showing the potential variability of Y if used in a forecast.

1. Regression Results and the Null Hypotheses

Whether the regression analysis was conducted on the aggregate annual data from AIRLANT or monthly data from 2nd MAW, the only relationship that consistently showed enough evidence to reject the null hypothesis was Flight Hours versus Fuel Costs. In some cases Total Cost was statistical significant. However, the compilation of the three major cost pools (Fuel, AFM, and AVDLR) into this one cost category usually diluted the strength of the Flight Hour v. Fuel relationship, causing it to lack the statistically significance required to show a direct relationship with Flight Hours. This tends to confirm many of the research conclusions presented from previous theses in Chapter II; that fuel frequently varies directly with flight hours, but AFM and AVDLR costs show a much weaker or no correlation with Flight Hours.

2. Regression Results and Aggregate Annual Data by FHP Category

AIRLANT and MARFORLANT TACAIR showed strong relationships between Fuel Cost and Flight Hours, however only MARFORLANT showed statistical significance in any other set of variables. (TACAIR Flight Hours v. Total Cost). Surprisingly, none of the cost relationships for MARFORLANT Fleet Air Training showed any statistical significance. In all cases, the maintenance categories (AFM and DLR) never came close to showing a strong correlation to flight hours. The results are listed below in Figure 5.2. Only the variable sets highlighted in gray are considered to be statistically significant.

AIRLANT Regression Results (FY95-98) **(Intercepts in 1000s of $)**

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-33032	-0.76	0.52	0.6975	7.46	0.02	96.5%	94.8%	55.72	0.01	5843
AFM v. Hours	394498	1.36	0.31	-0.1202	-0.19	0.86	1.8%	0.5%	0.03	0.86	39474
DLR v. Hours	830318	2.19	0.16	-0.2237	-0.27	0.81	3.6%	0.4%	0.07	0.81	51677
Totl v. Hours	1191783	3.61	0.07	0.35	0.49	0.67	10.6%	0.3%	0.24	0.67	44967

Figure 5.2. Regression Results by Organizational/Functional Category

Marine TACAIR Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-17319	-1.63	0.24	0.8083	7.54	0.02	96.6%	94.9%	56.83	0.02	3393
AFM v. Hours	91502	1.82	0.21	0.03	0.06	0.96	0.0%	0.5%	0	0.96	15998
DLR v. Hours	121055	2.19	0.16	0.4645	0.83	0.49	25.6%	0.1%	0.69	0.49	17665
Totl v. Hours	121055	2.19	0.16	2.4645	4.4	0.05	90.6%	85.9%	19.38	0.047	17665

Marine Fleet Air Training Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-11464	-0.51	0.66	1.1566	0.86	0.48	27.3%	0.1%	0.75	0.48	1319
AFM v. Hours	-9343	-0.18	0.87	1.314	0.43	0.71	8.4%	0.4%	0.18	0.71	3031
DLR v. Hours	39097	0.5	0.66	-0.9563	0.2	0.86	2.0%	0.5%	0.04	0.86	4636
Totl v. Hours	18269	0.16	0.88	1.5144	0.23	0.84	2.6%	0.5%	0.05	0.84	6485

Figure 5.2 (Continued)

3. Regression Results by Aircraft Type

The regression analysis results by selected aircraft type in 2nd MAW's inventory showed similar tendencies, where only fuel showed statistical significance regardless of the type of aircraft. However, regression results using monthly data points from the 2nd MAW DOLARS database failed to produce results with strong coefficients of determination. Even more surprisingly, the correlation of fuel cost to flight hours was never greater than 46.2 %. Also, the CH-46E showed some statistically significant correlation with four out of five of its data sets. (Hours v. Fuel, Hours v. AFM, Hours v. DLR, Hours v. Total Cost).

Lag regression results were only included in the tables if they showed statistical significance. This technique revealed few results that indicated a time lag was the cause of low coefficients of determination. Figure 5.3 displays regression results by type.

Marine AV-8B Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	a	T	P	B	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-1099	-1.85	0.21	0.7229	16.17	0.00	99.2%	98.8%	261	0.004	289.2504
AFM v. Hours	18406	15.88	0.00	-0.3242	-3.71	0.07	87.3%	80.9%	13.78	0.065	564.8663
DLR v. Hours	33148	20.41	0.00	-0.1136	-0.92	0.45	30.1%	0.0%	0.861	0.451	791.6548
Totl v. Hours	50455	16.83	0.00	0.2851	1.26	0.33	44.3%	16.5%	1.59	0.334	1461.143

AV-8B Regression Results (FY 95-98 –Monthly Data)

X v. Y	A	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	191590	1.16	0.25	547.87	4.02	0.00	26.0%	24.4%	16.17	0	327034
Fuel(-1) v. Hrs	131778	0.81	0.42	604.5	4.47	0.00	30.8%	29.3%	20.02	0	319747
Flt E. v. Hours	4705	0.83	0.41	9.199	1.97	0.06	7.8%	5.7%	3.87	0.06	11230

Figure 5.3. Regression Results by Type

AFM v. Hours	1122969	7.77	0.00	-20.9	-0.02	0.86	0.1%	0.0%	0.03	0.86	286139
AFM(-3) v. Hrs	1560903	10.63	0.00	-278.3	-2.27	0.03	10.7%	8.7%	5.17	0.03	288354
DLR v. Hours	2831993	4.56	0.00	27.1	0.05	0.96	0.0%	0.0%	0	0.96	1229115
DLR(-6) v. Hrs	3899819	6.10	0.00	-853.7	-1.56	0.13	5.8%	3.4%	2.45	0.13	1226734
Totl v. Hours	415257	6.06	0.00	563.2	1.00	0.32	2.1%	0.0%	0.99	0.32	1356914

Marine CH-46E Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	A	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-897.412	-1.43	0.29	0.2241	6.35	0.02	95.2%	92.9%	40.26	0.02	171.272
AFM v. Hours	19399.3	3.38	0.08	-0.016	-0.04	0.67	32.8%	10.8%	0.24	0.67	1577.395
DLR v. Hours	7124.78	0.98	0.43	1.0537	2.57	0.12	76.8%	65.3%	6.64	0.12	1982.576
Totl v. Hours	25626.6	7.10	0.02	1.118	5.46	0.03	93.7%	90.6%	29.87	0.03	991.960

CH-46E Regression Results (FY 95-98 – Monthly Data)

X v. Y	A	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	30278	1.89	0.06	174.1	8.98	0.00	46.2%	45.6%	80.62	0.00	57381
Flt E. v. Hours	15963	3.03	0.00	13.243	2.08	0.04	4.4%	3.4%	4.32	0.04	18862
AFM v. Hours	306356	4.58	0.00	530.98	6.56	0.00	31.4%	30.7%	43.04	0.00	239501
DLR v. Hours	409411	2.58	0.01	919.6	4.79	0.00	19.6%	18.8%	22.95	0.00	567993
Totl v. Hours	762009	4.22	0.00	1637.9	7.49	0.00	37.4%	36.7%	56.06	0.00	647351

Marine F-18(All models) Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	A	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-1038.61	-1.15	0.28	1.11	14.05	0.00	95.1%	94.6%	197.0	0.00	647.810
AFM v. Hours	5296.86	0.79	0.45	0.4192	0.71	0.49	4.8%	0.0%	0.5	0.49	4820.494
DLR v. Hours	14329.7	1.21	0.26	0.3627	0.35	0.73	1.1%	0.0%	0.12	0.73	8537.386
Totl v. Hours	18588.0	1.06	0.31	1.8919	1.24	0.24	13.3%	4.6%	1.53	0.24	12507.410

F-18(All models) Regression Results (FY 95-98- Monthly Data)

X v. Y	A	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	606623	7.72	0.00	524.72	5.51	0.00	17.6%	17.0%	30.38	0.00	389873
Flt E. v. Hours	7015	1.24	0.21	2.648	0.39	0.70	0.1%	0.0%	0.15	0.70	27983
AFM v. Hours	567260	6.08	6.80	37.1	0.37	0.71	0.1%	0.0%	0.13	0.71	413934
DLR v. Hours	1402135	5.04	0.00	-232.8	-0.69	0.49	0.3%	0.0%	0.48	0.49	1379534
Totl v. Hours	2583034	7.14	0.00	331.4	0.76	0.45	0.4%	0.0%	0.57	0.45	1796071

Figure 5.3 (Continued)

4. Interpretation of the Results by Cost Pool

While the regression analyses for each data set presented cannot prove conclusively that fuel costs vary directly according to the number of flight hours, and also cannot conclusively prove that maintenance costs are solely fixed, the measures of statistical significance and goodness of fit do provide evidence to support these hypotheses. Several key implications and possibilities should be considered for each cost pool when interpreting these results.

a. Flight Hours vs. Fuel Costs

The statistical evidence of this relationship seems strongest to support an already widely accepted conclusion that fuel costs do vary closely with the number of hours flown. This is not surprising. However, what is surprising is the low correlation of Hours v. Fuel Costs in the monthly DOLARS regression data. These results do not fit well with the high correlation found in Arkley's research. This may be a result of one or a combination of three possibilities. First, in 2nd MAW fuel costs may be reported as fuel stocks are purchased based on the need of the supporting agency and not in relation to when fuel is actually consumed by aircraft. There is some evidence of this. For example, in the analysis of the AV-8B, the regression revealed a higher R^2 when using a one-month time lag for the AV-8B. Second, there may be other factors unaccounted for that are difficult to quantify using monthly data. These factors may include the types of missions an aircraft is flying during a particular month, the environment in which the aircraft is operating and its effect on fuel consumption, and the aircraft payload during different mission types and its effect on fuel. Third, the adjustment index used is for an average of all types of aviation fuel used. Therefore, the effect of the index on monthly data of a specific aircraft type may cause inaccuracies that could be corrected by developing a more precise fuel escalation index for each particular type of aircraft.

b. Flight Hours vs. Flight Equipment Costs

This cost pool was only analyzed because it is included in 2nd MAW monthly obligation and cost per hour reports. Flight Equipment Costs include administrative costs of the FHP and equipment costs for the personal equipment of both the pilots and crew of aircraft. Therefore, the results showing no correlation of this cost category with Flight Hours seems logical. Admittedly, extended use of flight equipment during operations eventually may lead to replacement, but it may take years for this to occur and is not well represented in the databases. Also, the total O&M dollars spent on this cost category in comparison to Fuel, AFM and AVDLR are virtually immaterial with respect to their effect on the annual formulation of MARFORLANT FHP budgets.

c. Flight Hours vs. AFM and AVDLR Costs

Regression results for these variables ranged from statistically significant relationships with a weak correlation to relationships with no statistical evidence of a correlation or variability whatsoever. Like Fuel and Flight Hours, this does not conclusively prove that there is no relationship, but seems to confirm anecdotal evidence that much of the cost of maintenance of an aircraft is fixed. Again, several factors may explain these results. First, these cost pools may not have been correctly adjusted

because the VAD index used to adjust data does not adequately explain the complexities of cost changes in the cost pools. For example, in his adjustment of Depot Level Maintenance Costs, Arkley was able to model the change in Mean Time Between Failures for the F-404 engine. However, no such dramatic fluctuations could be developed for the particular types of aircraft analyzed in this thesis. Secondly, some of the aviation maintenance costs may be related to flight hours, such as the service life of individual components on an aircraft. However, others may not have any relationship, such as the change in the price of parts from year to year related to the acquisition process, or the regular interval that maintenance support personnel must conduct preventive maintenance checks on aircraft regardless of hours flown. (termed Phase Inspections)

To find supporting evidence to explain why there was no correlation between flight hours and maintenance costs, further interviews were conducted with personnel at 2nd MAW. Several logical arguments were presented by 2nd MAW personnel that supported the absence of correlation with flight hours. First, although the AFM and AVDLR cost pools are officially presented in FHP documents as distinct cost pools representing different maintenance functions, there is a mixing of similar costs and functions between the two cost pools. This would impede the development of any effective cost adjustment index, regardless of a more detailed research effort to develop one. Chapter II stated that the official purpose of the AFM cost pool was to record the costs of consumable material used for the repair of aircraft, aircraft components and aircraft ground support equipment. These types of consumables might include frequently used parts from pre-expended bins, stock list and expendable supplies such as tools, rags and special clothing. Other items included in the cost pool are frequently used parts such as rivets, resistors, and O-rings, and other commonly used maintenance material such as lubricants, and chemicals for corrosion control. In contrast, the official purpose of Aviation Depot Level Repairables is to capture the cost of replacing repairable components that are either unauthorized to be repaired by an intermediate maintenance activity (IMA) or cannot be repaired because the IMA echelon does not have the capability to accomplish the repair. However, it can also include the repair of operations support equipment which clearly is not related to flight hours. [Ref. 88] Reality at 2nd MAW and its supporting base organizations is that both the intermediate maintenance organizations within the wing support structure of 2nd MAW have the technical capability to perform depot level maintenance, and often do so. Therefore, this would tend to

pollute the AFM cost pool with costs that technically are supposed to be Depot Level costs. [Ref. 89]

Another plausible explanation for the finding that maintenance costs do not correlate as well as the results from Arkley's research is that the cost pools are less distinct than reserve cost pools. Instead of being broken down into pools that stem from each organization of maintenance, the AFM and AVDLR cost pools are maintained in the OFC-50 OPTARS maintained by the Marine Air Logistics Squadrons (MALS) belonging to each air group. At 2nd MAW all Organizational Maintenance funds are controlled by the MALS and collected within the MNT cost pool. Therefore, there is no way to separate these costs from Intermediate Maintenance Activity costs in the way that Arkley did. [Ref. 90]

In addition, both cost pools must bear the cost of several different maintenance activities that are clearly a fixed cost unrelated to time. For example, depot level agencies funded through FHP dollars often have annual pre-assigned goals of the number of Complete Engine Repairs (CERs) they must perform annually. However, which agency that actually performs the maintenance to meet an annual maintenance goal is not strictly defined. It may be conducted by an intermediate level agency, a depot level agency, or by a civilian contractor. In addition, for certain types of agencies the engines repaired may not be on 2nd MAW engines, since many of the depot level repair within AIRLANT is based on reciprocative agreements. Other fixed costs include the repair of ground support equipment, fixed price contracts for corrosion control costs and technical representatives, and the cost of unanticipated no notice technical directives that require the comprehensive replacement or repair of particular parts. For example, in FY97 a technical directive in response to a fatal crash of a CH-53E helicopter mandated that the bearings associated with the helicopter swashplate be checked. A swashplate is a mechanism beneath the rotors of the helicopter which transfers power to change the pitch of rotor blades. The action of checking the bearings caused most of the swashplates to be replaced at considerable cost. The FY98 cost of a swashplate assembly was over $69,000 per unit. [Ref. 91]

5. Implications for the Aviation Budget Officer and the FHP

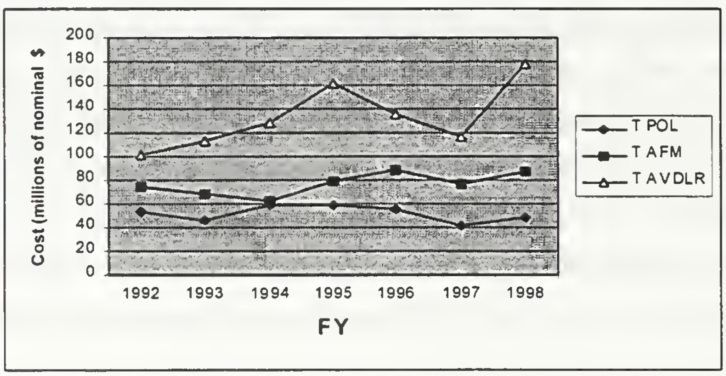
The regression results produced from this thesis research combined with the key findings of other FHP research outlined in Chapter II, provide evidence that the Cost Per Hour method of allocating funds in the Flying Hour Program is only defensible for fuel costs. In terms of OFC-50 costs for Aviation Fleet Maintenance and Aviation Depot Level Repairables, using Cost Per Hour as a measure to justify the need for additional

maintenance funds appears to be misleading and inaccurate. This is because fixed costs that are expressed in a cost per unit format are subject to change if the level of activity is different than the projected estimate. For example, Cost Per Hour for Aviation Depot Level Repairables would be higher than predicted if the number of hours flown was less than the number of hours budgeted.

The evidence provided in this and other research does not change the fact that Cost Per Hour is still the accepted measure for funding in the Flying Hour Program. Therefore, the Aviation Budget Officer must rely on detailed historical data and the experience of 2nd MAW maintenance and budgeting personnel to help him justify MARFORLANT maintenance needs in a way that both gains approval of the budgeting administrative chain of command and accurately states the needs of MARFORLANT.

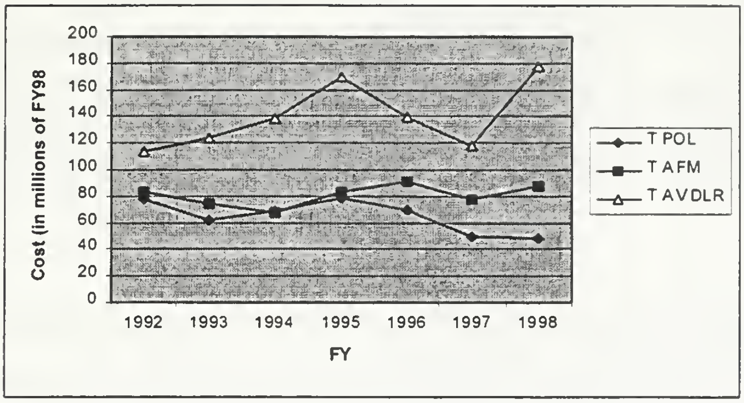
C. ALTERNATIVE ANALYSES OF FHP DATA

This section presents alternative analyses based on historical trends of cost, force structure, and flight hour execution. It also briefly compares the cost of TACAIR at MARFORLANT with MARFORPAC. First, a comparison of the annual cost of MARFORLANT TACAIR reflects the recent increasing maintenance costs discussed in Chapters II and III. Whether this trend is analyzed in nominal dollars, constant 1998 dollars, or as a percentage of total cost, the analysis shows that AVDLR costs are an obstacle to the future financial stability of the FHP. Figure 5.4 illustrates these trends.

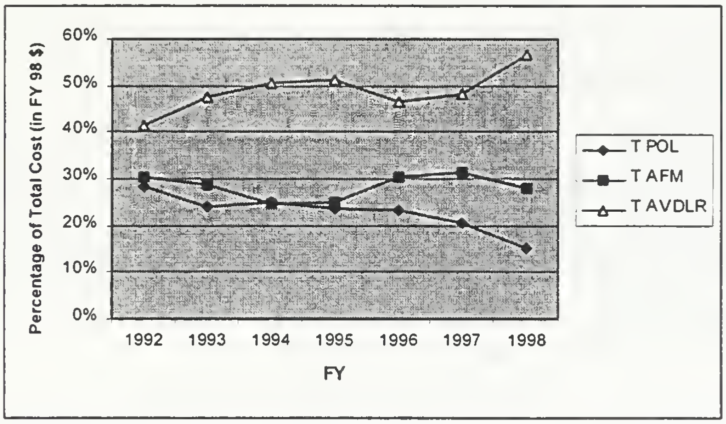


Annual Cost of MARFORLANT TACAIR in Nominal $ by Cost Pool

Figure 5.4. Comparison of MARFORLANT TACAIR Cost Pools



Annual Cost of MARFORLANT TACAIR in FY 98 $ by Cost Pool



Cost of MARFORLANT TACAIR As a Percentage of Total Cost by Cost Pool

Figure 5.4 (Continued)

In addition, these increases in maintenance costs have occurred while the total number of aircraft authorized and the total number of hours executed through the MACP have significantly decreased. Figure 5.5 displays two tables illustrating these trends.

MARFORLANT TACAIR Budgeted v. Executed Flight Hours

FY	Actual	Programmed	% Executed
1995	120021	117501	102.1%
1996	104488	108671	96.2%
1997	80983	83923	96.5%
1998	84572	86791	97.4%

Figure 5.5. MARFORLANT Historical Trends for Aircraft Authorized and Flight Hours

MARFORLANT TACAIR Aircraft Authorized							
	ALL	AV-8B	CH-46E	CH-53E	F-18A	F-18C	F-18D
1996	363	63	73	35	36	22	35
1997	332	62	69	31	28	24	35
1998	306	53	61	29	25	21	33

Figure 5.5 (Continued)

In addition, Figure 5.5 also shows that the switch to sortie based flight planning has not adversely affected the ability of MARFORLANT to execute its programmed number of flight hours.

A comparison of MARFORLANT trends to MARFORPAC did not reveal any significant differences in cost and flight hour execution trends. In particular, a comparison of the percentage of total cost for the three primary FHP cost pools showed no significant differences. In addition, regression analysis was conducted on MARFORPAC TACAIR data from 1995-1998. The results showed no significant difference compared to MARFORLANT. Figure 5.6 shows the comparison of MARFORLANT and MARFORPAC cost pools. Figure 5.7 shows the MARFORPAC TACAIR regression results.

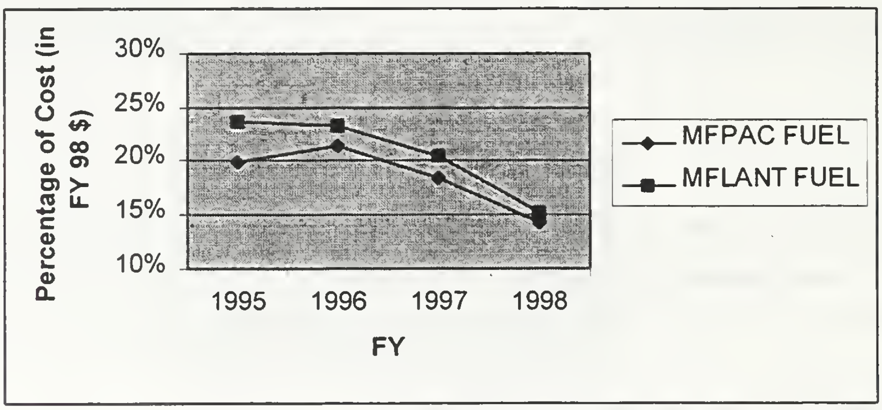
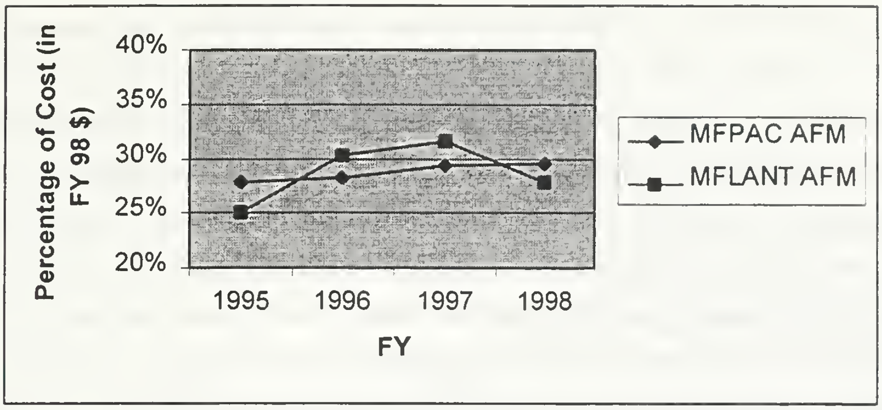


Figure 5.6. MARFORPAC vs. MARFORPAC Cost Pool Comparison



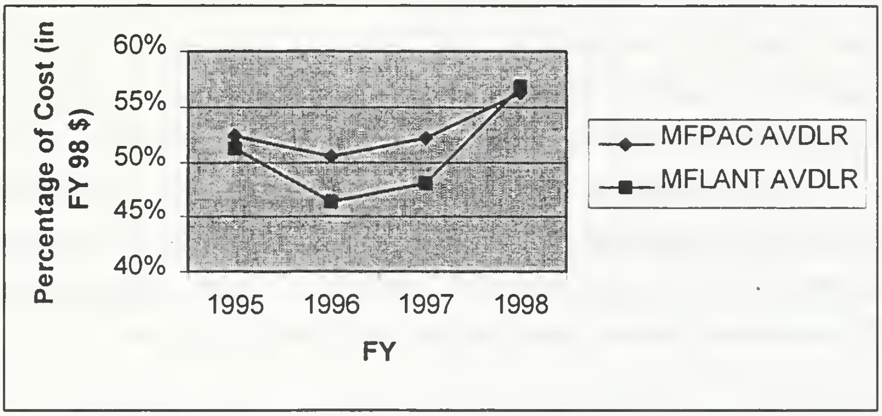


Figure 5.6 (Continued)

Marine Forces Pacific TACAIR Regression Results from AIRPAC Cost Reports
MFPAC TACAIR Regr Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	A	T	P	B	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-24582	-2.63	0.12	0.64135	10.2	0.01	98.1%	97.1%	104.5	0.009	1761.7
AFM v. Hours	136902	9.84	0.01	-0.01215	-1.28	0.33	45.0%	17.5%	1.63	0.328	2664.3
DLR v. Hours	244084	8.67	0.01	-0.17248	-0.89	0.46	28.7%	0.0%	0.8	0.463	5392.5
Totl v. Hours	356405	21.75	0.00	0.3474	3.1	0.09	82.8%	74.2%	9.66	0.089	3138.8

Figure 5.7. MARFORPAC TACAIR Regression Results

D. OPTIONS FOR FORECASTING FUTURE COSTS

The results of quantitative analysis of the Flying Hour Program at MARFORLANT are helpful in explaining cost behavior. Since statistical analysis

suggests that fuel costs exhibit variable cost behavior while maintenance costs exhibit fixed cost behavior, the MARFORLANT Aviation Budget Officer should be wary of budget adjustments in the OP-20 model that treat AFM and AVDLR as variable costs. These conclusions may be used to dispute the underfunding of MARFORLANT maintenance and AVDLR OPTARs during annual and mid-year budget negotiations with higher commands. However, the fact that the Aviation Budget Officer understands flaws in the OP-20 budgeting model does not make it any easier to predict precisely what MARFORLANT will need in future budgets. Fuel costs may be relatively predictable, but as the quantitative analysis shows, fuel cost is never more than 25% of the total cost of the FHP. If the rest of the FHP cost is relatively fixed, what is the best way to predict this cost?

Unless a better regression model can be developed both for the aggregate annual cost of the Flying Hour Program and also for the cost of flying individual types of aircraft at the wing level or below, regression analysis as a forecasting tool is unlikely to be any more effective than the current method. The reason for this is not that regression cannot estimate a forecasted cost, or cannot be used as a budgeting tool, but simply that the statistical variability of the fixed costs in the model are too great, and reduce confidence in the accuracy of the model. The results of Hours v. Total Cost from MARFORLANT TACAIR annual cost data in Figure 5.8 may be used as an example.

Marine TACAIR Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se
Totl v. Hours	121055	2.19	0.16	2.4645	4.4	0.05	90.6%	85.9%	19.38	0.047	17665

Regression Formula for Total Cost (in $1000s) = 2.4645(HOURS)

Figure 5.8. MARFORLANT TACAIR: Hours vs. Total Cost

First, despite the statistical significance of the overall model, the fixed costs represented by the coefficient, **a**, are not statistically significant. This reflects the reality that the fixed costs in the model are not predictable from year to year. From another perspective, the Standard Error of the Estimate (Se) is $17.665 million dollars. Therefore, using this model, the Aviation Budget Officer would have a confident level of 0.9 that the actual annual cost of his forecast would be within ± 2 standard deviations of the prediction. In other words, ± (2 x 17.665 million) = ± 35.33 million dollars. This type of variability may help explain bowwaves, but it does little to help the Aviation

Budget Officer to have confidence in an alternative forecast. Thus, some of the limitations of regression as a forecasting tool are exposed.

Another possible method might be to forecast using a statistical add-in program such as "Crystal Ball". This method would attempt to model the variability of MARFORLANT FHP cost pools using a simulation of fixed costs. Marines with a detailed knowledge of fixed costs within the AFM and AVDLR cost pools could assign probabilities for the likelihood of an expected cost range for each variable. The fixed cost variables would then be compiled in a spreadsheet, that showed the total estimated cost of AFM and AVDLR. The add-in program then would run a Monte Carlo simulation so that a significant number of trials helped to determine the likelihood of AFM and AVDLR fixed costs. Although the assignment of probabilities to cost estimates is as subjective as the cost estimates themselves, this method has the advantage of being able to draw upon the experience of those more familiar with the cost behavior of components of fixed maintenance costs. However, like regression analysis, the use of a Monte Carlo simulation cannot eliminate unforeseeable changes in fixed costs. In addition, the time consuming nature of developing this cost estimate could prohibit its use.

Ultimately, fixed costs must be predicted and supported in the same manner as they have been since the inception of PPBS. The key personnel with a knowledge of the expected cost of maintenance make their best estimate based on experience. Then the annual budget negotiations to justify budget submissions are held. In the end, the budget politics outlined in Chapter II dominate the final determination of the number of hours and the cost of the Flying Hour Program.

E. ANALYSIS OF FHP AS A MANAGEMENT CONTROL SYSTEM

Despite the understanding of Flying Hour Program cost behavior gained from quantitative analysis, the Aviation Budget Officer still faces the task of securing sufficient funding for MARFORLANT Aviation in the face of a complex budgeting environment. Simons' Levers of Control provides a framework that helps to understand the tensions inherent in the implementation of the Flying Hour Program and the MACP as budgeting strategies. This section provides an analysis of the MACP and the FHP within this context, and the implications of this analysis for the Aviation Budget Officer.

The final section of Chapter II summarized the four levers of control, that cause opposing tension during the implementation of any management strategy. These four levers are beliefs systems, boundary systems, interactive control systems, and diagnostic control systems. In review, Simons describes belief systems and interactive control

systems as the positive forces of management control, while boundary systems and diagnostic control systems are the negative forces of control. When Marine Aviation at MARFORLANT is placed in the context of this framework, the four levers of control are represented by many of the systems and strategies analyzed in this thesis. These are listed in bullets below.

- **Marine Aviation Belief Systems= Marine Aviation Core Values**

  - ⇨ Central Core Value to Marine Aviation.....Operational Readiness
  - ⇨ Central Core Value to MACP...Long Term Readiness
  - ⇨ Fiscal Integrity

- **Boundary Systems = Aviation Risks to Be Avoided**

  - ⇨ Aviation Safety Standards
  - ⇨ Aviation Maintenance Standards
  - ⇨ Standards of Quality of Life for Marines
  - ⇨ Legal and Procedural Budgeting Standards
  - ⇨ Formal and Informal Systems of Discipline

- **Diagnostic Control Systems = Aviation Critical Performance Variables**

  - ⇨ Measurement Systems of Operational and Maintenance Readiness
  - ⇨ Budgeting Systems: PPBS, FHP

- **Interactive Control Systems = Strategic and Management Planning**

  - ⇨ Master Plans for Aviation
  - ⇨ Mark and Reclama Process
  - ⇨ Informal Networks and Negotiated Solutions

The systems, standards and ideas are the relevant "Levers of Control" that the MARFORLANT Aviation Budget Officer faces in trying to execute his primary duty: to maintain the fiscal integrity of MARFORLANT Aviation. Maintaining fiscal integrity through the Flying Hour Program has a direct impact on the core value of aviation readiness. However, the Marine Aviation Campaign Plan presents an additional

approach: that future readiness should not be sacrificed at the expense of maintaining current readiness.

Even though the common goal inherent to the MACP is to maintain both current and future operational readiness, the mere statement of this goal does not guarantee its achievement. Pilots, commanding officers, maintenance officers, budget officers, and the rest of the personnel involved in achieving this vision are restricted in their efforts by the rules and norms of FHP and PPBS. They face considerable formal and informal boundaries that attempt to ensure certain standards are not sacrificed to achieve operational ends. Aviation Safety standards seem to be the most obvious and critical of all the standards that protect Marine Aviation from unacceptable risk. However, just as critical are the capabilities of Marines to do their jobs. In this way, the Marine Aviation Campaign Plan set several standards that needed to be met to ensure the comprehensive health of Marine Aviation.

These standards are monitored by several traditional systems described in this thesis. The monitoring systems, called diagnostic control systems, provide feedback as to whether the beliefs and visions for Marine Aviation are being met, and whether boundaries are being violated in the process. The many formal and informal rules of the FHP, PPBS, and the budget allocation and execution systems provide this feedback on fiscal matters. However, as the 2nd MAW cost data demonstrated, sometimes the validity and usefulness of the data is limited. Likewise, readiness reports and the assessments of commanders and staff in the chain of command provide limited measures of operational and logistical readiness.

The Department of the Navy and DOD have well developed, traditional management control systems for these first three levers. However, the fourth lever of control, Interactive Control Systems, seems to be the least well developed of the process. The interactive control system is supposed to stimulate the search for new strategies to achieve goals in the face of uncertainty. At the highest levels of DON, this is what the PPBS and FHP systems are supposed to accomplish. However, because of the sheer size of the Department of the Navy, and because of the entrenched positions and fiscal strategies of the other service departments and Congress, these systems oftentimes do not produce the most efficient or fiscally responsible action. Instead, these systems oftentimes produce disincentives to act in the best interests of their organization and run against their belief systems. A frequently used but unattributed anecdote about misincentives within the Flying Hour Program is how squadrons flew additional hours or dumped fuel in the middle of flights to achieve their cost and flight hour targets. The

justification for these actions is that unless they fully spend their funds by the end of the fiscal year, would lose funding in next year's budget.

The volume of boundaries and internal controls limiting the action of commanding officers, comptrollers, and other decision makers has constrained their ability to make significant improvements in aviation readiness. Yet the Marine Aviation Campaign Plan is unique because it has reduced the effect of several inherent, unwritten rules of the FHP an PPBS in favor of the appropriate ends. Most significantly, the aspect of the Plan that cuts flight hours in an unprecedented number and then expects the cost savings from these hours to pay for simulator acquisition breaks several unwritten rules about budgeting. Perhaps the most significant disincentive built into the rules of the budget process is that when an agency states it can accomplish its mission with fewer resources, the resources saved are often withdrawn in punishment vice reward for savings behavior.

In addition, the Marine Aviation Campaign Plan causes FHP and other DON budgeting methods to be examined and debated as to whether MACP goals are being accomplished or thwarted. Chapter II explained the four characteristics of interactive control systems. First, the system must generate information analyzed on a recurring basis to be addressed by the higher level managers. Second, the interactive control system demands regular attention from operating managers at all levels. Third, the data must be interpreted and discussed in face to face meetings of superiors, subordinates and peers. Fourth, the system is a catalyst for the continual challenge of underlying data, assumptions and action plans. [Ref. 92] In itself, the FHP does not embody these characteristics. However, as part of the MACP, the FHP has been given new life in several ways. First, by demanding sortie based planning for operations from flight hour based planning, the MACP has made it simpler for commanders to focus on their mission of operational readiness. Second, the achievement of all the goals of the MACP must be accomplished by Marines at all levels, and thus the MACP is a catalyst for new ideas and a means for stimulating debate over whether the goals of MACP are being achieved. Finally, from a budgeting perspective, the MACP provides incentive to all levels of Marine Aviation to use the correct means to achieve the specified goals of the program, i.e., to maintain long term readiness without sacrificing current readiness.

The implications for the Aviation Budget Officer at MARFORLANT are similar to the conclusions drawn from regression forecasting. Publishing the plan does not ensure its executability, and requires vigilant monitoring and cooperation by key players managing the FHP. MACP requires the Aviation Budget Officer to be continuously engaged in monitoring the costs of Marine Aviation, determining and debating the fiscal

needs for Marine Aviation in the future. This can only be done by actively scrutinizing and debating the inputs, outputs, and consequences of the FHP with seniors and subordinates, accomplished with analysts, Marines and Sailors up and down the budgeting chain of command.

A recent example of this process at work occurred at a team budget meeting at NAVCOMPT to address concerns that the combination of a maintenance "bowwave" and underfunding of the FHP in budget outyears would jeopardize the MACP. At the root of the problem is increasing maintenance costs and the desire of FMB analysts to fall back on the use of budgeting habits to cut Marine Aviation funding because flight hours (PMR) were not being executed. The intervention of the Vice Chief of Naval Operations and the Assistant Commandant of the Marine Corps provided visibility to the problem, and budgeting shortfalls were corrected after a meeting of many of the key players in the budgeting chain of command ranging from representatives of 2nd MAW to NAVCOMPT.

F. SUMMARY

In summary, this chapter presented regression analysis and results for Hours vs. Cost Pool relationships. In addition, alternative use of quantitative methods to explain the current state of the FHP at MARFORLANT was analyzed. This was followed by an analysis of the qualitative dynamics of Marine Aviation at MARFORLANT as part of management control systems framework. The central theme of the chapter is that despite the seeming strength of statistical methods, the Aviation Budget Officer must ultimately rely on the experience of aviation operations and maintenance experts, and on a network of contacts to ensure that the FHP is fully funded.

VI. CONCLUSIONS AND RECOMMENDATIONS

Within the context of the challenges that confront the aviation community, this thesis examined and analyzed three major components of the Flying Hour Program at U.S. Marine Forces Atlantic. Understanding these components is essential to answering the primary research question, "How should the Flying Hour Program be managed at MARFORLANT to maximize its value to Marine Aviation."

The first component of this thesis analyzes the federal and Department of Defense budget process, and its consequences for budgeting for MARFORLANT. Chapters II and III analyzed critical parts of this process including the impact of congressional budgeting, the Planning, Programming and Budgeting System, and the dynamics resulting from complexity in the operational and administrative chains of command.

The second component analyzed the historical background and the organization of the Flying Hour Program. The basic OP-20 model was analyzed relative to its relationship with TACAIR, Fleet Air Training and Fleet Air Support program elements of the FHP. Current problems with the Flying Hour Program and its impact on MARFORANT Aviation was assessed.

The third component analyzed the Flying Hour Program utilizing both quantitative and qualitative analysis. Cost behavior from monthly and annual FHP cost data bases was analyzed using regression and time-series analysis to determine whether MARFORLANT cost behavior is were similar to that found in previous research on the FHP. The Flying Hour Program and related budgeting systems were analyzed within the context of the Marine Aviation Campaign Plan.

A. SUMMARY OF SECONDARY RESEARCH QUESTIONS

Seven secondary research questions were answered in the thesis to provide context and to answer the primary research question.

1. What are the historical trends of flying hour program budgeting and execution?

Chapter III and Chapter V present data on the historical trends of FHP budgeting and execution at MARFORLANT. The majority of FHP funds at MARFORLANT fund tactical aviation (TACAIR). Therefore, TACAIR was the focus of analysis. Time series analysis showed that Fuel and Aircraft Fleet Maintenance have been relatively stable in constant dollars over the past seven years. However, Aviation Depot Level Repairables

have been continually increasing in cost due to a complex combination of aviation logistics and budgeting problems. Some of these problems are described in Chapters II and III. Research demonstrated that the primary budgeting agency for MARFORLANT TACAIR, the 2nd Marine Aircraft Wing, has generally executed its programmed flight hours within four percent of its goals. Implementation of the Marine Aviation Campaign Plan has significantly reduced the total number of hours flown annually since 1996.

2. How has the switch from flying hour based budgeting to event based budgeting affected Marine Aviation at MARFORLANT?

Initial research showed that this question did not accurately describe what was occurring as a consequence of the institution of the Marine Aviation Campaign Plan. Interviews with the MARFORLANT Aviation Budget Officer and 2nd MAW Comptroller revealed that programmed hours have been slightly underexecuted due to the conversion of the MACP. "In FY 97, the first real year of the (Marine) Aviation Campaign Plan, 2nd MAW flew 65,447 sorties/98,208 hours." [Ref. 93] The sortie based goal for FY 98 was 71, 948 sorties/105,438 hours. [Ref. 94] Again, this goal was underexecuted. The current tendency of sortie based planning seems to confirm underexecution of the budgeted hours from N-88. However, this has not yet critically impacted MARFORLANT because of the willingness of the budgeting chain of command to give the MACP a chance to improve flight hour program management.

At the MARFORLANT level, the Aviation Budget Officer deals with the budgeting chain of command strictly in terms of flight hours for both budget formulation and execution. Therefore, other than the underexecution of hours, the impact on MARFORLANT administration of the program is minimal. In the future, two problems may develop with the MACP approach to planning and execution. First, the advantage of planning by sorties may be lost if MARFORLANT Aviation Budgets are cut as a consequence of underexecution of hours. Second, attempts to fly more hours even though training is planned by sortie may cause behaviors that run counter to the "better management" intent of the Marine Aviation Campaign Plan.

3. What are the budgeting dynamics that currently threaten full funding of MARFORLANT's aviation programs?

Budgeting dynamics are explored throughout the thesis. They may be grouped into three types: organizational dynamics, procedural dynamics, and impact on cost behavior. Examples of organizational dynamics that threaten full funding range from the annual struggle to obtain adequate dollars from Congress, to the efforts of MARFORLANT to justify budget priorities to higher level DOD administrative agents.

Procedural dynamics include PPBS complexity and the difficulty of predicting the future costs of the Flight Hour Program. Cost behavior effects were explained primarily using regression analysis.

Analysis of cost behavior illustrated three points about cost data at MARFORLANT. First, only fuel costs showed consistent statistical significance as a dependent variable of the number of flight hours flown. In addition, fuel costs for 2nd MAW monthly data were statistically significant, but did not demonstrate strong correlation to flight hours. Second, the lack of statistical significance and correlation of maintenance costs to flight hours suggests one or a combination of three possibilities: (a) that maintenance costs are largely fixed, (b) that finding parametric means of explaining maintenance costs is difficult, and (c) that the cost pools as they are compiled in the active duty FHP databases have many overhead and fixed costs that explain why correlation is low. The MARFORLANT Aviation Budget Officer should be mindful that few analysts and participants in the FHP budget process understand these cost behaviors. Therefore, MARFORLANT should be wary to watch for analysis that cuts flying budgets under the assumption that all costs vary directly with flight hours.

4. What is the financial condition of the MARFORLANT Aviation program compared with MARFORPAC, and if there is a difference, what explains the differences?

In comparing MARFORLANT with MARFORPAC, no significant differences were found in budgeting and cost behavior. Although the command size and budget of MARFORPAC are larger than MARFORLANT, regression analysis of MARFORPAC annual TACAIR data showed similar cost behavior to MARFORLANT. Also, as a percentage of total cost, the FHP cost pools of MARFORPAC versus MARFORLANT do not differ by more than 5% per year in any cost pool. Environmental factors account for these differences including weather, operational requirements, and training conditions. However, these factors were not analyzed in this thesis because of the small difference between the cost pools.

5. Can new financial models be developed to more accurately capture the realities of MARFORLANT aviation?

Although some previous research by Arkley suggested that regression analysis can be used as an effective tool to forecast flying hour costs, the results from analysis in Chapter V showed that this probably will not work for MARFORLANT. There are two reasons supporting this conclusion. First, the costing systems used by Active duty Navy and Marine forces do not capture maintenance costs in the same way they are captured for

Navy and Marine Corps Reserve units. Second, the unpredictability of maintenance costs, AVDLR in particular, has become the critical problem affecting the accuracy of FHP forecasts. The regression results from this thesis suggest that unless better adjustments of maintenance data are developed, regression forecasts may have too much variability to be used as a primary means for prediction.

6. Can simulation be used to test the accuracy of current and alternative aviation cost models at MARFORLANT?

A Monte Carlo simulation could be used as an alternative to regression forecasting. However, the time needed to develop such a model would probably prohibit its usefulness at MARFORLANT. In addition, until a better understanding of all maintenance costs is developed, this simulation probably would provide give any more assurance about future fixed costs than methods used presently.

7. What future budgeting and operating adjustments does MARFORLANT need to make to successfully meet the goals of the Marine Aviation Campaign Plan?

The MARFORLANT Aviation Budget Officer must monitor one basic problem in keeping the Marine Aviation Campaign Plan intact. That problem is out-year underfunding. To do this, he must ensure that Program Objectives Memorandum OP-20s and Budget Execution OP-20s are not underfunded either in hours or cost. This is because the Marine Corps is reliant on the projected cost savings of MACP to fund the purchase of simulators, and because the Marine Corps wants to avoid a penalty for flying less hours in the interests of the long range logistical health of its airframes.

B. SUMMARY OF THE PRIMARY RESEARCH QUESTION

Despite the findings from previous research cited in Chapter II that implied a new FHP forecasting model could be developed through regression analysis, the quantitative analysis in this thesis showed some of the pitfalls of regression as a forecasting tool for the FHP. Given the nature of MARFORLANT cost pools, regression analysis can be helpful as a supplemental tool, but it cannot relieve the Aviation Budget Officer of uncertainty in estimating the annual cost of the Flying Hour Program. Arkley commented in his thesis that, "…incremental increasing, or decreasing budget requests based on a 'gut feel' of the future is no longer an acceptable planning method." [Ref. 95] However, given the flaws of the OP-20 model in improperly modeling maintenance costs, budget execution judgement based on the observations of experienced individuals at all levels of the Department of the Navy and MARFORLANT spectrum still plays the most

important role in determining annual spending totals. Analysis of the FHP and PPBS processes reveals that obtaining adequate funding for MARFORLANT Aviation is as much a result of the dynamics of budget politics and support networks as it is the result of proper modeling of FHP cost.

Therefore, considering the answers to the secondary research questions and the uncertainty of budgeting for future conditions, the following recommendations are intended to assist the MARFORLANT Aviation Budget Officer in effectively managing the FHP.

1. Since the majority of FHP funds in MARFORLANT flow to 2nd MAW aviation programs, the MARFORLANT Aviation Budget Officer is much more of an advocate and liaison for 2nd MAW to higher echelons of command than a manager of FHP funds. This is because, unlike MARFORPAC, 2nd MAW is the only Tactical Air Wing under MARFORLANT. Its staff and experience level are greater than the Aviation Budget Officer staff at MARFORLANT. Therefore, the MARFORLANT Aviation Budget must rely on the estimates and experience of 2nd MAW in recommending the best budgeting courses of action to the MARFORLANT Comptroller and to higher budgeting agencies.

2. The MARFORLANT Aviation Budget Officer must continually improve knowledge and build budgeting networks to be in the best position to obtain adequate funding of the FHP. This requires becoming familiar with the three major components of the FHP presented in the beginning of Chapter VI: the overarching context of DOD budgeting, the organization and adminstration of the FHP, and the cost behavior and organizational behavior of the aviation budgeting process. In particular, the Aviation Budget Officer should be wary of efforts to cut the budget based upon incorrect assumptions about the FHP, as explained in Chapter II.

3. As the analysis of the Marine Aviation Campaign Plan illustrates, the MARFORLANT Aviation Budget Officer should not always follow the most conservative (unwritten) rules of budgeting reviewed in Chapter V. However, the potential risks of deviation from a conservative budgeting methodology must be carefully considered. Most importantly, deviation from standard budgeting techniques requires the support not only of the agencies that are effected directly, such as the Commanding General MARFORLANT or Commanding General 2nd MAW, but also requires the support of the administrators and analysts in the budgeting chain of command that NAVCOMPT.

C. RECOMMENDATIONS FOR FURTHER STUDY

Further research on the components of the OFC-50 cost pools may better reveal the cost behavior of Aviation Fleet Maintenance Costs and Aviation Depot Level Repairable Costs. The primary research question would be to determine effective ways for forecasting the fixed and variable costs in these cost pools. This research also could better explain the fixed and variable nature of those cost pools.

In addition, in several more years research into the comprehensive successes and failures of the Marine Aviation Campaign Plan would provide insight into how the norms of the federal budgeting process and budget execution control in the Marine Corps ought to be changed.

Finally, a detailed analysis of the effect of Navy Working Capital Fund Surcharges and changes in Value of Annual Demand (VAD) could provide a better explanation of Aviation Fleet Maintenance and Aviation Depot Level Repairables price changes and how this effects FHP budgeting. This was the topic least understood by all personnel contacted in the research for the thesis.

D. CONCLUSION

The Marine Corps Flying Hour Program at MARFORLANT is characterized by similar cost behavior and budgeting dynamics compared to that found through research conducted elsewhere in the Department of the Navy. Regression results of MARFORLANT cost data revealed that the OP-20 model correctly models Fuel Costs as directly variable with flight hours. However, maintenance costs related to flight hours were not statistically significant (with little or no correlation). A possible conclusion as a result of this analysis is that maintenance and aviation depot level repairable costs are fixed or mostly fixed, and thus are incorrectly modeled for budgeting in the OP-20. While the OP-20 model has flaws for use in forecasting, no regression model was defined in this thesis to provide an adequate enough forecast to consider replacing the OP-20. Rather, analysts and budgeteers must be wary of the forecasts in the OP-20 and weigh OP-20 accuracy against the use of alternative forecasting methods. Consequently, the MARFORLANT Aviation Budget Officer still must understand the human, organizational, operational and logistical dynamics of budgeting to obtain adequate funding for Marine Aviation. Well prepared, logical budget justifications supported by credible statistics are still the best tools available to the Aviation Budget Officer to satisfy the responsibility for obtaining the financial resources needed to support the MARFORLANT mission.

APPENDIX A.

MARFORLANT DISTRIBUTION OF NAVY O&M FUNDS

	Funding Category	FY 97	FY 98
MARFORLANT DISTRIBUTION (Comptroller)			
	SDT (TOT)	$8,529,000	$8,484,000
2D MARINE AIRCRAFT WING ONLY			
	TACAIR Fuel	39,143,500	50,318,000
	TACAIR Admin	1,386,750	1,760,000
	TACAIR AFM	69,084,000	71,198,000
	TACAIR AVDLR	106,565,600	163,224,964
	sub-total	$216,179,850	$286,500,964
	Fleet Air Training Fuel	9,005,000	7,100,000
	Fleet Air Training Admin	510,000	240,000
	Fleet Air Training AFM	10,250,785	13,800,000
	Fleet Air Training AVDLR	19,905,365	24,000,000
	sub-total	$39,671,150	$45,140,000
	LF6F AFM	6,085,000	9,765,000
	LF6F AVDLR	9,302,000	13,335,000
	Cross Fleet AFM	3,818,000	4,009,154
	Cross Fleet AVDLR	7,300,000	7,338,027
	sub-total	$26,505,000	$34,447,181
	OP-20 Total	$282,356,000	$366,088,145
	IMRL	324,000	1,639,475
	Aircraft Operations	5,248,000	4,742,047
	TAD	6,591,000	6,263,494
	sub-total	$12,163,000	$12,645,016
	2nd MAW Total	$294,519,000	$378,733,161
HMX-1 ONLY	Fuel	2,075,000	2,015,000
	Admin	289,000	395,413
	AFM	2,912,000	3,347,016
	AVDLR	2,931,000	5,682,144
	sub-total	$8,207,000	$11,439,573
	IMRL	342,000	330,215
	AC OPS	214,000	233,369
	TAD	3,297,000	4,834,638
	sub-total	$3,853,000	$5,398,222
	HMX-1 Total	$12,060,000	$16,837,795
COMCABEAST ONLY			
	Fuel	2,329,385	2,165,639
	Admin	212,000	259,500

AFM	3,973,899	3,728,463
AVDLR	1,723,400	2,728,526
sub-total	$8,238,684	$8,882,128
IMRL	163,000	166,310
AC OPS	274,316	321,584
TAD	427,000	662,740
sub-total	$864,316	$1,150,634
CABEAST Total	$9,103,000	$10,032,762
MARFORLANT FHP/NON-FHP TOTAL	$324,211,000	$414,087,718

APPENDIX B. COMPREHENSIVE COST AND FLIGHT HOUR DATA

AIRLANT Annual Flying Hour Program Cost Data (in millions of nominal $)

YEAR	TOTAL HOURS	TOTAL FUEL	TOTAL AFM	TOTAL AVDLR	TOTAL COST
1992	593099	$269.531	$293.966	$455.087	$1,018.584
1993	545837	$235.904	$294.273	$502.435	$1,032.612
1994	498344	$267.356	$254.009	$529.836	$1,051.201
1995	498344	$233.529	$284.962	$678.536	$1,197.027
1996	479171	$243.083	$294.651	$551.896	$1,089.630
1997	427110	$223.692	$288.295	$561.374	$1,073.361
1998	428330	$261.368	$323.007	$785.627	$1,370.002

Marine TACAIR Annual Flying Hour Program Cost Data (in millions of nominal $)

YEAR	TOTAL HOURS	TOTAL FUEL	TOTAL AFM	TOTAL AVDLR	TOTAL COST
1992	125,418	$53.159	$74.162	$101.471	$228.792
1993	113,587	$46.313	$68.017	$112.599	$226.929
1994	112,137	$58.492	$62.923	$128.637	$250.052
1995	120,021	$58.840	$79.041	$161.648	$299.529
1996	104,488	$55.464	$88.222	$135.217	$278.903
1997	80,983	$41.710	$75.990	$115.972	$233.672
1998	84,572	$47.857	$87.209	$177.485	$312.551

Marine Fleet Replacement Squadron Annual Flying Hour Program Cost Data (in millions of nominal $)

YEAR	TOTAL HOURS	TOTAL FUEL	TOTAL AFM	TOTAL AVDLR	TOTAL COST
1992	17102	$7.320	$8.741	$9.005	$25.066
1993	16268	$6.705	$8.850	$15.047	$30.602
1994	16762	$8.469	$7.422	$14.932	$30.823
1995	16762	$6.697	$8.196	$16.874	$31.767
1996	17307	$6.970	$11.140	$18.040	$36.150
1997	16909	$5.981	$10.653	$19.905	$36.539
1998	16010	$6.328	$14.092	$27.201	$47.620

Marine AV-8B (TACAIR only) Annual Flying Hour Program Cost Data (in millions of nominal $)

YEAR	TOTAL HOURS	TOTAL FUEL	TOTAL AFM	TOTAL AVDLR	TOTAL COST
1992	21775	$10.989	$15.407	$14.644	$41.040
1993	17936	$8.725	$14.346	$26.086	$49.157
1994	16158	$8.932	$9.920	$24.140	$42.992
1995	17213	$8.356	$11.599	$28.926	$48.881
1996	14745	$7.850	$11.111	$24.877	$43.838
1997	10019	$5.081	$12.297	$25.604	$42.982
1998	9503	$5.722	$15.266	$32.638	$53.626

Marine CH-46E (TACAIR only) Annual Flying Hour Program Cost Data
(in millions of nominal $)

YEAR	TOTAL HOURS	TOTAL FUEL	TOTAL AFM	TOTAL AVDLR	TOTAL COST
1992	21724	$2.308	$11.662	$16.586	$30.556
1993	22889	$2.447	$10.676	$17.931	$31.054
1994	20781	$2.845	$9.990	$14.182	$27.017
1995	21111	$2.834	$14.604	$27.418	$44.856
1996	18086	$2.645	$13.959	$19.758	$36.362
1997	14664	$2.024	$14.441	$17.346	$33.811
1998	16054	$2.552	$15.268	$26.324	$53.626

Marine CH-53E (TACAIR only) Annual Flying Hour Program Cost Data
(in millions of nominal $)

YEAR	TOTAL HOURS	TOTAL FUEL	TOTAL AFM	TOTAL AVDLR	TOTAL COST
1992	6988	$2.107	$5.940	$8.864	$16.911
1993	7696	$2.347	$5.531	$10.231	$18.109
1994	7604	$2.846	$6.171	$13.508	$22.525
1995	7591	$2.574	$7.820	$19.001	$29.395
1996	6287	$2.218	$9.338	$16.367	$27.923
1997	6086	$2.138	$8.106	$11.962	$22.206
1998	6830	$2.713	$9.247	$21.274	$33.234

Marine F-18 (TACAIR only) Annual Flying Hour Program Cost Data
(in millions of nominal $)

YEAR	T/M/S	TOTAL HOURS	TOTAL FUEL	TOTAL AFM	TOTAL AVDLR	TOTAL COST
1992	F-18A	19723	$15.682	$14.778	$21.683	$52.143
1993	F-18A	19123	$14.677	$10.758	$21.797	$47.232
1994	F-18A	17366	$14.786	$8.797	$22.939	$46.522
1995	F-18A	14294	$11.036	$7.869	$18.267	$37.172
1996	F-18A	13338	$10.770	$17.291	$27.196	$55.257
1997	F-18A	8165	$6.422	$11.089	$21.064	$38.575
1998	F-18A	8897	$7.707	$12.916	$30.778	$51.401
1992	F-18C	5013	$4.327	$0.349	$0.367	$5.043
1993	F-18C	5450	$4.181	$3.118	$6.318	$13.617
1994	F-18C	6535	$6.966	$3.343	$8.717	$19.026
1995	F-18C	11398	$9.314	$6.295	$14.613	$30.222
1996	F-18C	9610	$8.482	$5.532	$9.445	$23.459
1997	F-18C	8826	$7.967	$4.017	$7.587	$19.571
1998	F-18C	8069	$7.411	$6.156	$13.961	$27.528
1993	F-18D	3187	$1.895	$1.715	$3.475	$7.085
1994	F-18D	10894	$7.826	$5.454	$14.222	$27.502
1995	F-18D	14953	$11.628	$8.319	$19.310	$39.257
1996	F-18D	13749	$11.064	$7.865	$9.140	$28.069
1997	F-18D	11275	$9.747	$9.437	$10.418	$29.602
1998	F-18D	11162	$11.198	$7.159	$13.470	$31.827

2nd MAW Cost Data By Type

AV8B Flight Hour and Cost Data
(in nominal $)

MONTH	YEAR	TYPE	UNIT	TOT HRS	7B (FUEL)	7F (FLT E)	7L (AFM)	9S(DLR)
OCT	1993	AV-8B	MAG-14	1502	404377	17656	983726	1208841
NOV	1993	AV-8B	MAG-14	1587	1387808	20444	1065726	3993832
DEC	1993	AV-8B	MAG-14	1265	940714	23271	1038230	2011457
JAN	1994	AV-8B	MAG-14	1339	821546	34987	1123930	1857766
FEB	1994	AV-8B	MAG-14	1348	764488	18908	917451	2404178
MAR	1994	AV-8B	MAG-14	1766	1035192	15315	977172	3014189
APR	1994	AV-8B	MAG-14	1324	1257645	140	1667121	1775139
MAY	1994	AV-8B	MAG-14	1531	1282844	4018	900314	2067036
JUNE	1994	AV-8B	MAG-14	1550	802270	12887	1166062	2290773
JULY	1994	AV-8B	MAG-14	1675	1373295	7372	1315474	3028675
AUG	1994	AV-8B	MAG-14	1026	1143338	13976	640037	2012645
SEP	1994	AV-8B	MAG-14	496	683145	-7047	462133	3558266
OCT	1994	AV-8B	MAG-14	1561	731463	14870	1206108	3531929
NOV	1994	AV-8B	MAG-14	1216	923898	16474	987739	2109321
DEC	1994	AV-8B	MAG-14	1372	465518	18933	1008006	2261507
JAN	1995	AV-8B	MAG-14	1593	868581	23474	774113	3029540
FEB	1995	AV-8B	MAG-14	1391	1211281	14637	914386	3713828
MAR	1995	AV-8B	MAG-14	1601	745056	14604	1354621	2333020
APR	1995	AV-8B	MAG-14	1333	956798	4535	822491	2176167
MAY	1995	AV-8B	MAG-14	1518	100419	30839	1174005	2440097
JUNE	1995	AV-8B	MAG-14	1125	842855	5251	293291	2172306
JULY	1995	AV-8B	MAG-14	1345	999299	46697	1284104	1605842
AUG	1995	AV-8B	MAG-14	1010	893291	14789	909028	2257422
SEP	1995	AV-8B	MAG-14	1296	874066	42131	800951	1582533
OCT	1995	AV-8B	MAG-14	1650	741812	23514	972789	3414815
NOV	1995	AV-8B	MAG-14	1554	555970	6925	911972	1793780
DEC	1995	AV-8B	MAG-14	1822	981330	21635	791611	1333825
JAN	1996	AV-8B	MAG-14	1667	895739	15246	983082	2230832
FEB	1996	AV-8B	MAG-14	2115	933669	15782	854062	2761881
MAR	1996	AV-8B	MAG-14	1416	392216	6326	1196282	2442672
APR	1996	AV-8B	MAG-14	1464	867922	18769	1221727	2595214
MAY	1996	AV-8B	MAG-14	1423	1063056	13899	1309351	2246438
JUNE	1996	AV-8B	MAG-14	1423	1489109	26439	1449470	2195582
JULY	1996	AV-8B	MAG-14	1139	970480	10871	1038954	1983706
AUG	1996	AV-8B	MAG-14	1171	514532	49449	1012595	3228143
SEP	1996	AV-8B	MAG-14	994	300067	-1386	888471	1147881
OCT	1996	AV-8B	MAG-14	545	292287	26493	1071448	2818908
NOV	1996	AV-8B	MAG-14	540	219499	8573	870316	1918145
DEC	1996	AV-8B	MAG-14	534	410435	5564	759340	1723215
JAN	1997	AV-8B	MAG-14	1162	470013	10323	895926	2515425
FEB	1997	AV-8B	MAG-14	898	896546	15681	1313721	3625735
MAR	1997	AV-8B	MAG-14	1206	312922	5486	1306360	3936498
APR	1997	AV-8B	MAG-14	1135	645481	5030	984683	3411195
MAY	1997	AV-8B	MAG-14	1056	815032	13496	985694	1815020

JUNE	1997	AV-8B	MAG-14	843	318581	7859	951949	2185724
JULY	1997	AV-8B	MAG-14	1067	525445	12793	1037602	346127
AUG	1997	AV-8B	MAG-14	992	429274	7833	1063585	1133512
SEP	1997	AV-8B	MAG-14	715	816134	4707	822263	3391960
OCT	1997	AV-8B	MAG-14	939	563038	10616	1554709	8012097
NOV	1997	AV-8B	MAG-14	910	627459	12767	1228490	3328630
DEC	1997	AV-8B	MAG-14	1150	570889	6454	1744568	1929010
JAN	1998	AV-8B	MAG-14	700	511724	6550	1301136	3818785
FEB	1998	AV-8B	MAG-14	767	503077	14874	1226841	3278228
MAR	1998	AV-8B	MAG-14	911	529215	14782	1673357	1729328
APR	1998	AV-8B	MAG-14	823	544532	8513	1850104	3800512
MAY	1998	AV-8B	MAG-14	761	589969	6342	849272	2408693
JUNE	1998	AV-8B	MAG-14	1049	576207	1906	1185793	1984557
JULY	1998	AV-8B	MAG-14	828	839309	17582	771002	1670196
AUG	1998	AV-8B	MAG-14	1089	712674	4516	938326	2456395
SEP	1998	AV-8B	MAG-14	946	784360	33992	1007345	1484119

CH46E Flight Hour and Cost Data
(in nominal $)

MON	YEAR	TYPE	UNIT	HOURS	7B (FUEL)	7F (FLT E)	7L (AFM)	9S(DLR)
NOV	1993	CH-46E	MAG-26	875	151818	34261	640318	989061
NOV	1993	CH-46E	MAG-29	651	115583	13773	293610	353855
DEC	1993	CH-46E	MAG-26	789	159195	25462	683627	613809
DEC	1993	CH-46E	MAG-29	507	95481	48125	341903	274182
JAN	1994	CH-46E	MAG-26	832	203133	22926	210134	955847
JAN	1994	CH-46E	MAG-29	381	123635	9558	236879	261738
FEB	1994	CH-46E	MAG-26	704	215274	13420	454894	521614
FEB	1994	CH-46E	MAG-29	514	101475	20746	431646	327725
MAR	1994	CH-46E	MAG-26	663	208090	1555	565035	969255
MAR	1994	CH-46E	MAG-29	854	119199	11270	422908	698209
APR	1994	CH-46E	MAG-26	712	196575	36696	382119	600765
APR	1994	CH-46E	MAG-29	959	103156	3203	411341	406906
MAY	1994	CH-46E	MAG-26	523	192100	14432	628321	850762
MAY	1994	CH-46E	MAG-29	890	124042	16666	510285	454138
JUNE	1994	CH-46E	MAG-26	563	251660	24667	1065368	806302
JUNE	1994	CH-46E	MAG-29	732	114956	17593	333951	703753
JULY	1994	CH-46E	MAG-26	612	182095	28599	532435	629913
JULY	1994	CH-46E	MAG-29	570	127916	5756	321089	115163
AUG	1994	CH-46E	MAG-26	415	197643	51513	862050	1598048
AUG	1994	CH-46E	MAG-29	484	121215	16191	335519	351702
SEP	1994	CH-46E	MAG-26	0	168918	21439	-322234	718260
SEP	1994	CH-46E	MAG-29	0	161329	16332	186855	492160
OCT	1994	CH-46E	MAG-26	976	147782	12321	966315	1445133
OCT	1994	CH-46E	MAG-29	637	97706	11401	457681	908440
NOV	1994	CH-46E	MAG-26	822	126483	8531	633547	788126
NOV	1994	CH-46E	MAG-29	620	104849	24168	354088	761341
DEC	1994	CH-46E	MAG-26	965	118449	45187	664594	1337259
DEC	1994	CH-46E	MAG-29	706	91252	23508	541093	669221
JAN	1995	CH-46E	MAG-26	1083	206919	10073	737560	1372776

JAN	1995	CH-46E	MAG-29	811	150582	33531	446602	1240017
FEB	1995	CH-46E	MAG-26	1277	230683	21126	779715	1171546
FEB	1995	CH-46E	MAG-29	735	101678	9643	628167	902235
MAR	1995	CH-46E	MAG-26	1129	175100	42207	655188	1111280
MAR	1995	CH-46E	MAG-29	718	106590	15047	585537	1472493
APR	1995	CH-46E	MAG-26	953	336446	7338	741112	1041586
APR	1995	CH-46E	MAG-29	591	96595	18565	412234	624079
MAY	1995	CH-46E	MAG-26	1327	177385	19421	970327	1147731
MAY	1995	CH-46E	MAG-29	743	86861	22022	438736	832077
JUNE	1995	CH-46E	MAG-26	1474	206409	22066	836130	1522621
JUNE	1995	CH-46E	MAG-29	407	125401	5858	370716	431309
JULY	1995	CH-46E	MAG-26	1402	301989	97090	619203	970194
JULY	1995	CH-46E	MAG-29	587	137535	14761	428201	1516043
AUG	1995	CH-46E	MAG-26	1281	52585	33077	780893	1334730
AUG	1995	CH-46E	MAG-29	793	172592	9305	403799	409251
SEP	1995	CH-46E	MAG-26	1139	192247	56147	620571	2026292
SEP	1995	CH-46E	MAG-29	685	111149	28867	572037	1471869
OCT	1995	CH-46E	MAG-26	1050	167308	12255	585990	556248
OCT	1995	CH-46E	MAG-29	1033	92203	17121	577741	1151765
NOV	1995	CH-46E	MAG-26	864	132284	3196	582650	2321728
NOV	1995	CH-46E	MAG-29	628	116531	6732	686925	540180
DEC	1995	CH-46E	MAG-26	940	136843	22795	639277	777406
DEC	1995	CH-46E	MAG-29	545	70127	11253	646303	557124
JAN	1996	CH-46E	MAG-26	1208	280334	13243	506227	1945556
JAN	1996	CH-46E	MAG-29	558	116519	5905	599190	871217
FEB	1996	CH-46E	MAG-26	1197	199817	23449	702896	1023028
FEB	1996	CH-46E	MAG-29	517	106151	47843	472365	839387
MAR	1996	CH-46E	MAG-26	1115	210987	9221	820383	1324533
MAR	1996	CH-46E	MAG-29	379	96052	5598	397334	841631
APR	1996	CH-46E	MAG-26	1371	223252	38171	938114	1540409
APR	1996	CH-46E	MAG-29	385	81100	16381	402667	319683
MAY	1996	CH-46E	MAG-26	1204	228566	35816	1086791	1273448
MAY	1996	CH-46E	MAG-29	572	150163	83511	477502	275626
JUNE	1996	CH-46E	MAG-26	888	198060	29974	1149189	1022916
JUNE	1996	CH-46E	MAG-29	544	140922	14735	369643	641271
JULY	1996	CH-46E	MAG-26	934	149368	26923	964918	1376441
JULY	1996	CH-46E	MAG-29	456	-16916	6699	324496	321826
AUG	1996	CH-46E	MAG-26	725	236026	1605	509946	1527504
AUG	1996	CH-46E	MAG-29	529	74914	27268	687287	906193
SEP	1996	CH-46E	MAG-26	550	155026	34917	367879	855815
SEP	1996	CH-46E	MAG-29	607	44587	24150	402673	205144
OCT	1996	CH-46E	MAG-26	816	158139	10328	715128	975641
OCT	1996	CH-46E	MAG-29	854	91822	74580	586577	943427
NOV	1996	CH-46E	MAG-26	605	113686	39388	468210	1019091
NOV	1996	CH-46E	MAG-29	425	61145	30499	547967	350577
DEC	1996	CH-46E	MAG-26	611	89294	43829	694192	844359
DEC	1996	CH-46E	MAG-29	278	52193	4955	405991	1086519
JAN	1997	CH-46E	MAG-26	895	116146	31365	1260397	791328
JAN	1997	CH-46E	MAG-29	285	80941	39086	429799	723356
FEB	1997	CH-46E	MAG-26	1080	139930	40303	778371	1368767

FEB	1997	CH-46E	MAG-29	271	78490	27498	417024	389220
MAR	1997	CH-46E	MAG-26	1287	164011	57049	933377	871682
MAR	1997	CH-46E	MAG-29	353	68736	7448	348061	134945
APR	1997	CH-46E	MAG-26	1124	151110	14875	740688	1869241
APR	1997	CH-46E	MAG-29	416	141313	23812	492918	877795
MAY	1997	CH-46E	MAG-26	1114	168676	28872	956747	1339829
MAY	1997	CH-46E	MAG-29	314	26022	-12464	607564	139507
JUNE	1997	CH-46E	MAG-26	669	195163	18782	623163	837449
JUNE	1997	CH-46E	MAG-29	439	79937	40500	414629	308764
JULY	1997	CH-46E	MAG-26	919	109717	26029	675904	370168
JULY	1997	CH-46E	MAG-29	521	90402	-16065	327993	-375610
AUG	1997	CH-46E	MAG-26	767	214864	27528	529991	862643
AUG	1997	CH-46E	MAG-29	587	63877	57104	593906	537923
SEP	1997	CH-46E	MAG-26	711	201395	3151	619985	2014916
SEP	1997	CH-46E	MAG-29	520	68119	21549	408105	1152809
OCT	1997	CH-46E	MAG-26	1082	191613	9122	1152071	2402194
OCT	1997	CH-46E	MAG-29	478	108396	25038	753545	1916995
NOV	1997	CH-46E	MAG-26	696	113074	31214	565562	1944924
NOV	1997	CH-46E	MAG-29	295	87154	3971	517601	1126645
DEC	1997	CH-46E	MAG-26	1123	125932	41420	869721	1154964
DEC	1997	CH-46E	MAG-29	363	95918	32697	417047	987830
JAN	1998	CH-46E	MAG-26	956	145818	15391	1288988	1116573
JAN	1998	CH-46E	MAG-29	436	106718	42389	570299	1424994
FEB	1998	CH-46E	MAG-26	769	122515	59428	751804	2162917
FEB	1998	CH-46E	MAG-29	551	94319	18003	433976	32937
MAR	1998	CH-46E	MAG-26	1031	242877	30854	1072992	869249
MAR	1998	CH-46E	MAG-29	605	135979	28943	563054	728370
APR	1998	CH-46E	MAG-26	812	180639	32139	1473656	1261701
APR	1998	CH-46E	MAG-29	658	115095	14744	793044	1924689
MAY	1998	CH-46E	MAG-26	748	169509	37238	545120	296566
MAY	1998	CH-46E	MAG-29	632	134939	13303	300135	936690
JUNE	1998	CH-46E	MAG-26	1032	202401	19231	1321807	-218078
JUNE	1998	CH-46E	MAG-29	625	113884	40016	223371	-290636
JULY	1998	CH-46E	MAG-26	1059	200909	43143	648710	1277864
JULY	1998	CH-46E	MAG-29	373	101736	35557	136801	285471
AUG	1998	CH-46E	MAG-26	1147	168733	29129	294446	1761890
AUG	1998	CH-46E	MAG-29	504	115140	4430	256542	631142
SEP	1998	CH-46E	MAG-32	1034	220862	34005	524069	1106591
SEP	1998	CH-46E	MAG-35	276	61911	61438	553765	726287

F-18 Flight Hour and Cost Data
(in nominal $)

MON	YEAR	TYPE	UNIT	HOURS	7B (FUEL)	7F (FLT E)	7L (AFM)	9S(DLR)
NOV	1993	FA-18A	MAG-31	1162	2506691	2058	813031	2894814
NOV	1993	FA-18C	MAG-31	411	719771	1125	174275	451516
NOV	1993	FA-18D	MAG-31	756	583770	306	170874	174123
DEC	1993	FA-18A	MAG-31	808	950869	6323	1077021	2932469
DEC	1993	FA-18C	MAG-31	379	367839	1419	180241	414211
DEC	1993	FA-18D	MAG-31	775	531433	7200	160592	226821
JAN	1994	FA-18A	MAG-31	901	1008917	5087	971313	2354210

JAN	1994	FA-18C	MAG-31	484	496490	875	52286	102435
JAN	1994	FA-18D	MAG-31	642	515676	3499	146538	283517
FEB	1994	FA-18A	MAG-31	1497	1462849	15142	369307	1243901
FEB	1994	FA-18C	MAG-31	491	446189	1566	288624	619728
FEB	1994	FA-18D	MAG-31	857	715164	8898	136855	103831
MAR	1994	FA-18A	MAG-31	1961	1696369	3959	1155956	2492231
MAR	1994	FA-18C	MAG-31	599	359446	1452	450761	986074
MAR	1994	FA-18D	MAG-31	783	759491	7521	241015	242754
APR	1994	FA-18A	MAG-31	1351	1536665	18774	824043	3062658
APR	1994	FA-18C	MAG-31	513	627782	236	261331	823554
APR	1994	FA-18D	MAG-31	891	417217	1196	212020	171864
MAY	1994	FA-18A	MAG-31	873	1429940	5621	1032351	2936628
MAY	1994	FA-18C	MAG-31	751	741656	42	76543	56191
MAY	1994	FA-18D	MAG-31	1327	943462	3479	272430	506338
JUNE	1994	FA-18A	MAG-31	731	1115711	15258	744120	2970793
JUNE	1994	FA-18C	MAG-31	899	663141	1866	119031	296519
JUNE	1994	FA-18D	MAG-31	1240	728939	6809	173348	161375
JULY	1994	FA-18A	MAG-31	953	971429	-165	458607	2082311
JULY	1994	FA-18C	MAG-31	671	842317	3765	257411	740258
JULY	1994	FA-18D	MAG-31	1100	842615	3641	287965	594624
AUG	1994	FA-18A	MAG-31	587	1293236	11672	544162	929752
AUG	1994	FA-18C	MAG-31	715	995208	7156	667018	1606162
AUG	1994	FA-18D	MAG-31	1302	1225958	10587	259501	487030
SEP	1994	FA-18A	MAG-31	114	281978	7202	256272	1904281
SEP	1994	FA-18C	MAG-31	428	689148	2223	47496	476265
SEP	1994	FA-18D	MAG-31	796	269638	-232	113230	326909
OCT	1994	FA-18A	MAG-31	842	873832	2363	326313	808899
OCT	1994	FA-18C	MAG-31	995	509585	17126	339841	1003447
OCT	1994	FA-18D	MAG-31	1132	479736	4019	249261	523548
NOV	1994	FA-18A	MAG-31	639	540111	13667	462439	1971258
NOV	1994	FA-18C	MAG-31	1001	657858	23808	153716	403068
NOV	1994	FA-18D	MAG-31	1013	388363	1844	287363	747868
DEC	1994	FA-18A	MAG-31	608	568401	2210	390814	1813848
DEC	1994	FA-18C	MAG-31	699	572118	2899	98958	158686
DEC	1994	FA-18D	MAG-31	1084	1072830	4191	258773	898443
JAN	1995	FA-18A	MAG-31	600	1610575	13544	638241	1872909
JAN	1995	FA-18C	MAG-31	920	1275945	6894	350466	708873
JAN	1995	FA-18D	MAG-31	1310	1340479	15702	582599	242129
FEB	1995	FA-18A	MAG-31	781	259127	5967	487855	2294076
FEB	1995	FA-18C	MAG-31	888	779840	14737	363284	717774
FEB	1995	FA-18D	MAG-31	1414	769416	141	234843	423306
MAR	1995	FA-18A	MAG-31	976	833323	6815	13951	-2679896
MAR	1995	FA-18C	MAG-31	754	430605	7753	709945	2454576
MAR	1995	FA-18D	MAG-31	1393	841485	6242	1224773	4665075
APR	1995	FA-18A	MAG-31	811	1251415	10225	2712907	9973412
APR	1995	FA-18C	MAG-31	482	968478	4221	92117	-938899
APR	1995	FA-18D	MAG-31	1186	1115680	5966	-1112551	-5139444
MAY	1995	FA-18A	MAG-31	946	1198732	2110	901089	759375
MAY	1995	FA-18C	MAG-31	502	866389	8018	227376	241820
MAY	1995	FA-18D	MAG-31	1369	1359399	17978	259943	152360

JUNE	1995	FA-18A	MAG-31	770	818140	5218	1228487	1477478
JUNE	1995	FA-18C	MAG-31	438	953349	9469	110766	137904
JUNE	1995	FA-18D	MAG-31	1463	1079584	3384	385237	293854
JULY	1995	FA-18A	MAG-31	780	1094618	2926	640596	1653249
JULY	1995	FA-18C	MAG-31	611	1035375	10001	332950	245161
JULY	1995	FA-18D	MAG-31	1286	1058677	4442	332947	686370
AUG	1995	FA-18A	MAG-31	806	1242122	3196	930880	2539158
AUG	1995	FA-18C	MAG-31	428	1212696	4766	133406	226816
AUG	1995	FA-18D	MAG-31	1330	1269107	9711	325047	766878
SEP	1995	FA-18A	MAG-31	739	1036497	43531	553991	1878947
SEP	1995	FA-18C	MAG-31	60	618634	14320	55686	145127
SEP	1995	FA-18D	MAG-31	1406	933587	9637	509717	551023
OCT	1995	FA-18A	MAG-31	813	1076946	7818	1239105	1612047
OCT	1995	FA-18C	MAG-31	240	609863	2989	304649	305004
OCT	1995	FA-18D	MAG-31	1422	1289563	19389	492354	741977
NOV	1995	FA-18A	MAG-31	652	712164	6848	480968	825123
NOV	1995	FA-18C	MAG-31	369	991735	10594	87057	216663
NOV	1995	FA-18D	MAG-31	1085	878424	-7408	230692	179416
DEC	1995	FA-18A	MAG-31	714	831105	6570	188327	2286138
DEC	1995	FA-18C	MAG-31	260	849102	620	278137	553391
DEC	1995	FA-18D	MAG-31	1279	1016255	26031	557148	712252
JAN	1996	FA-18A	MAG-31	659	675752	6584	1443715	1473691
JAN	1996	FA-18C	MAG-31	231	670366	2957	905108	1003360
JAN	1996	FA-18D	MAG-31	1278	1660585	11917	1431605	948755
FEB	1996	FA-18A	MAG-31	758	549783	4463	453921	1337785
FEB	1996	FA-18C	MAG-31	446	831691	0	406312	771075
FEB	1996	FA-18D	MAG-31	1429	425892	12639	512872	386756
MAR	1996	FA-18A	MAG-31	588	1195222	15756	1225499	2148441
MAR	1996	FA-18C	MAG-31	588	631402	30760	541707	932864
MAR	1996	FA-18D	MAG-31	1156	909445	1016	507015	459969
APR	1996	FA-18A	MAG-31	961	1224139	4777	1220074	1561598
APR	1996	FA-18C	MAG-31	812	771486	4037	-439513	-615474
APR	1996	FA-18D	MAG-31	1263	1379456	1034	1296326	1350450
MAY	1996	FA-18A	MAG-31	958	2262395	3209	1330647	2547474
MAY	1996	FA-18C	MAG-31	744	656173	1786	512473	733415
MAY	1996	FA-18D	MAG-31	1113	670653	526	753329	1042063
JUNE	1996	FA-18A	MAG-31	618	-647665	1795	895072	1340477
JUNE	1996	FA-18C	MAG-31	695	640839	7496	430014	336937
JUNE	1996	FA-18D	MAG-31	1242	1059081	6227	844256	510437
JULY	1996	FA-18A	MAG-31	758	1165671	3358	1225190	2384566
JULY	1996	FA-18C	MAG-31	634	526385	3222	492966	598099
JULY	1996	FA-18D	MAG-31	1027	850262	18447	565210	1055588
AUG	1996	FA-18A	MAG-31	658	727523	-605	1369939	1694212
AUG	1996	FA-18C	MAG-31	1117	915875	4805	409983	555870
AUG	1996	FA-18D	MAG-31	977	835527	11914	639555	1037996
SEP	1996	FA-18A	MAG-31	448	1226220	13532	372246	1463997
SEP	1996	FA-18C	MAG-31	514	620220	5472	318799	500012
SEP	1996	FA-18D	MAG-31	841	587745	-17082	479932	899395
OCT	1996	FA-18A	MAG-31	526	706483	10509	626999	1301739
OCT	1996	FA-18C	MAG-31	917	800509	13419	424457	495127

OCT	1996	FA-18D	MAG-31	1048	867384	4818	588118	533100
NOV	1996	FA-18A	MAG-31	411	720370	3604	570311	979628
NOV	1996	FA-18C	MAG-31	474	443332	10390	357911	653111
NOV	1996	FA-18D	MAG-31	768	661082	9522	570954	870930
DEC	1996	FA-18A	MAG-31	357	475787	2614	876108	806275
DEC	1996	FA-18C	MAG-31	275	532510	15884	520689	305929
DEC	1996	FA-18D	MAG-31	785	731936	11981	949425	732076
JAN	1997	FA-18A	MAG-31	174	345463	-418	1418468	2249258
JAN	1997	FA-18C	MAG-31	400	754905	10089	678059	547471
JAN	1997	FA-18D	MAG-31	983	859810	230362	989456	998384
FEB	1997	FA-18A	MAG-31	259	493575	2513	869457	1485651
FEB	1997	FA-18C	MAG-31	406	722812	15527	415111	573247
FEB	1997	FA-18D	MAG-31	842	631201	-215187	688018	677859
MAR	1997	FA-18A	MAG-31	429	577063	21831	343506	922261
MAR	1997	FA-18C	MAG-31	429	699503	9485	148907	151992
MAR	1997	FA-18D	MAG-31	1395	334897	6289	272721	678888
APR	1997	FA-18A	MAG-31	388	534036	-7967	434072	1202595
APR	1997	FA-18C	MAG-31	423	833249	5093	286026	509932
APR	1997	FA-18D	MAG-31	1178	1705368	9039	887440	1681516
MAY	1997	FA-18A	MAG-31	382	490493	5600	674408	725943
MAY	1997	FA-18C	MAG-31	620	869814	15919	472112	591627
MAY	1997	FA-18D	MAG-31	1213	893065	14046	866935	952733
JUNE	1997	FA-18A	MAG-31	246	661085	1474	421316	1156521
JUNE	1997	FA-18C	MAG-31	767	493726	1525	204520	316072
JUNE	1997	FA-18D	MAG-31	847	683807	22401	420720	497390
JULY	1997	FA-18A	MAG-31	412	501356	9963	411052	402693
JULY	1997	FA-18C	MAG-31	589	646946	8093	378058	119114
JULY	1997	FA-18D	MAG-31	935	985512	8868	509164	66914
AUG	1997	FA-18A	MAG-31	629	509965	5615	374926	1050867
AUG	1997	FA-18C	MAG-31	809	696811	15089	297022	333126
AUG	1997	FA-18D	MAG-31	1020	832673	21457	576020	389043
SEP	1997	FA-18A	MAG-31	576	631700	27255	643957	2530528
SEP	1997	FA-18C	MAG-31	497	756691	24049	410690	744938
SEP	1997	FA-18D	MAG-31	930	1053437	16686	1002629	1820337
OCT	1997	FA-18A	MAG-31	945	898731	1786	874981	5020915
OCT	1997	FA-18C	MAG-31	356	878903	3869	307902	897718
OCT	1997	FA-18D	MAG-31	1096	1160928	6967	733976	1488200
NOV	1997	FA-18A	MAG-31	442	468814	7784	1029022	3447526
NOV	1997	FA-18C	MAG-31	166	677667	5362	415248	944734
NOV	1997	FA-18D	MAG-31	704	754966	6221	825916	1548756
DEC	1997	FA-18A	MAG-31	609	576960	11518	1846555	2245952
DEC	1997	FA-18C	MAG-31	197	681787	15378	404386	572629
DEC	1997	FA-18D	MAG-31	980	773665	1255	791919	1077290
JAN	1998	FA-18A	MAG-31	755	774737	1057	843136	2321225
JAN	1998	FA-18C	MAG-31	224	502066	16622	421376	1112200
JAN	1998	FA-18D	MAG-31	1081	1076945	10681	854492	1778130
FEB	1998	FA-18A	MAG-31	382	786954	9164	857341	2436872
FEB	1998	FA-18C	MAG-31	232	720529	5120	396266	1154819
FEB	1998	FA-18D	MAG-31	1092	1251342	8516	770519	2291589
MAR	1998	FA-18A	MAG-31	406	990358	6361	668281	1744423

MAR	1998	FA-18C	MAG-31	314	370478	9542	537497	524983
MAR	1998	FA-18D	MAG-31	1123	910855	11871	1015206	2723376
APR	1998	FA-18A	MAG-31	391	865086	9078	1121603	1908746
APR	1998	FA-18C	MAG-31	439	583694	7460	516840	938875
APR	1998	FA-18D	MAG-31	955	1147110	10381	754105	1414732
MAY	1998	FA-18A	MAG-31	379	1012366	7372	756272	1585512
MAY	1998	FA-18C	MAG-31	595	809032	16472	393638	602565
MAY	1998	FA-18D	MAG-31	1021	1141810	17018	516849	945277
JUNE	1998	FA-18A	MAG-31	193	448154	1536	821222	2320329
JUNE	1998	FA-18C	MAG-31	664	687775	9502	481224	1092614
JUNE	1998	FA-18D	MAG-31	1059	1368378	4034	562439	1418457
JULY	1998	FA-18A	MAG-31	172	652947	17313	708065	1871424
JULY	1998	FA-18C	MAG-31	824	784076	6817	547155	1116463
JULY	1998	FA-18D	MAG-31	960	1295254	12499	705944	1684354
AUG	1998	FA-18A	MAG-31	335	862857	4068	903044	1396578
AUG	1998	FA-18C	MAG-31	961	991255	9218	540985	300644
AUG	1998	FA-18D	MAG-31	1104	933480	3411	887902	842186
SEP	1998	FA-18A	MAG-31	367	871815	17749	507358	2723016
SEP	1998	FA-18C	MAG-31	885	693068	26730	314055	849442
SEP	1998	FA-18D	MAG-31	704	1397114	27576	386546	528382

APPENDIX C. REGRESSION ANALYSIS TABLES

Regression Results from AIRLANT Annual Flying Hour Cost Reports

AIRLANT Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	A	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-33032	-0.76	0.52	0.6975	7.46	0.02	96.5%	94.8%	55.72	0.01	5843
AFM v. Hours	394498	1.36	0.31	-0.1202	-0.19	0.86	1.8%	0.5%	0.03	0.86	39474
DLR v. Hours	830318	2.19	0.16	-0.2237	-0.27	0.81	3.6%	0.4%	0.07	0.81	51677
Totl v. Hours	1191783	3.61	0.07	0.35	0.49	0.67	10.6%	0.3%	0.24	0.67	44967

Regression Formula for Fuel Cost (in $1000s) = .6975(HOURS)

Marine TACAIR Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	A	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-17319	-1.63	0.24	0.8083	7.54	0.02	96.6%	94.9%	56.83	0.02	3393
AFM v. Hours	91502	1.82	0.21	0.03	0.06	0.96	0.0%	0.5%	0	0.96	15998
DLR v. Hours	121055	2.19	0.16	0.4645	0.83	0.49	25.6%	0.1%	0.69	0.49	17665
Totl v. Hours	121055	2.19	0.16	2.4645	4.4	0.05	90.6%	85.9%	19.38	0.047	17665

Regression Formula for Fuel Cost (in $1000s) = .8083(HOURS)

Regression Formula for Total Cost (in $1000s) = 2.4645(HOURS)

Marine Fleet Air Training Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	A	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-11464	-0.51	0.66	1.1566	0.86	0.48	27.3%	0.1%	0.75	0.48	1319
AFM v. Hours	-9343	-0.18	0.87	1.314	0.43	0.71	8.4%	0.4%	0.18	0.71	3031
DLR v. Hours	39097	0.5	0.66	-0.9563	0.2	0.86	2.0%	0.5%	0.04	0.86	4636
Totl v. Hours	18269	0.16	0.88	1.5144	0.23	0.84	2.6%	0.5%	0.05	0.84	6485

Marine AV-8B Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	A	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-1099	-1.85	0.21	0.7229	16.17	0.00	99.2%	98.8%	261	0.004	289.2504
AFM v. Hours	18406.58	15.88	0.00	-0.3242	-3.71	0.07	87.3%	80.9%	13.78	0.065	564.8663
DLR v. Hours	33148	20.41	0.00	-0.1136	-0.92	0.45	30.1%	0.0%	0.861	0.451	791.6548
Totl v. Hours	50455	16.83	0.00	0.2851	1.26	0.33	44.3%	16.5%	1.59	0.334	1461.143

Regression Formula for Fuel Cost (in $1000s) = .72294(HOURS)

Marine CH-46E Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	A	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-897.412	-1.43	0.29	0.2241	6.35	0.02	95.2%	92.9%	40.26	0.024	171.272
AFM v. Hours	19399.31	3.38	0.08	-0.016	-0.049	0.67	32.8%	10.8%	0.241	0.671	1577.395
DLR v. Hours	7124.784	0.98	0.43	1.0537	2.57	0.12	76.8%	65.3%	6.642	0.123	1982.576
Totl v. Hours	25626.69	7.1	0.02	1.118	5.46	0.03	93.7%	90.6%	29.87	0.032	991.9605

Regression Formula for Fuel Cost (in $1000s) = .2241(HOURS)

Regression Formula for Total Cost (in $1000s) = 25626.69 + 1.118(HOURS)

Marine CH-53E Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-561.752	-0.49	0.67	0.5128	3.01	0.09	90.5%	81.9%	9.079	0.094	198.351
AFM v. Hours	21309.76	2.89	0.10	-1.7075	-1.56	0.26	54.9%	32.3%	2.43	0.258	1274.724
DLR v. Hours	2886.073	0.15	0.89	2.4504	0.862	0.48	27.1%	0.1%	0.744	0.479	3310.643
Totl v. Hours	23634	0.93	0.45	1.2557	0.332	0.77	5.2%	0.4%	0.11	0.77	4395.181
Alternative											
Fuel v Hours (FY92-FY98)	-69.9223	-0.1	0.92	0.438	4.38	0.01	79.3%	75.4%	19.18	0.007	160.3032

Regression Formula for Fuel Cost (in $1000s) = .437968(HOURS)

Marine F-18(All models) Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-1038.61	-1.15	0.28	1.11	14.05	0.00	95.1%	94.6%	197	0	647.8103
AFM v. Hours	5296.868	0.79	0.45	0.4192	0.712	0.49	4.8%	0.0%	0.5	0.492	4820.494
DLR v. Hours	14329.77	1.21	0.26	0.3627	0.35	0.73	1.1%	0.0%	0.121	0.735	8537.386
Totl v. Hours	18588.02	1.069	0.31	1.8919	1.24	0.24	13.3%	4.6%	1.53	0.243	12507.41

Regression Formula for Fuel Cost (in $1000s) = 1.11(HOURS)

Marine F-18A Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-2556	-2.74	0.11	1.2056	14.87	0.00	99.1%	98.6%	221.07	0.004	434.0637
AFM v. Hours	12616	0.83	0.49	0.1477	0.11	0.92	0.0%	0.0%	0.01	0.92	7045.47
DLR v. Hours	31950	1.85	0.20	-0.3774	-0.25	0.82	3.0%	0.4%	0.06	0.82	8025.368
Totl v. Hours	42010	1.32	0.31	0.976	0.35	0.76	5.9%	0.0%	0.12	0.756	14743

Regression Formula for Fuel Cost (in $1000s) = 1.2056(HOURS)

Marine F-18C Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-3387	-1.21	0.32	1.4138	5.15	0.04	92.9%	89.4%	26.53	0.035	678.58
AFM v. Hours	3059	0.77	0.52	0.3339	0.8	0.51	24.4%	0.0%	0.64	0.51	1027
DLR v. Hours	3453	0.31	0.78	0.9802	0.84	0.48	26.3%	0.0%	0.71	0.48	2863
Totl v. Hours	3125	0.26	0.82	2.7278	2.2	0.15	70.9%	56.3%	4.87	0.16	3055

Regression Formula for Fuel Cost (in $1000s) = 1.4138(HOURS)

Marine F-18D Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-531	-0.61	0.60	1.0641	15.83	0.00	99.2%	98.8%	250.7	0.003	218.1885
AFM v. Hours	9387	1.04	0.40	0.0023	0.003	0.99	0.0%	0.0%	1.04	0.99	2262
DLR v. Hours	-3575	0.24	0.83	1.4247	1.23	0.34	43.3%	14.9%	1.52	0.341	3743
Totl v. Hours	5280	0.355	0.75	2.491	2.16	0.16	70.0%	55.0%	4.67	0.16	3740

Regression Formula for Fuel Cost (in $1000s) = 1.0641(HOURS)

Regression Results from 2nd MAW DOLARS Monthly Reports

F-18(All models) Regression Results (FY 95-98- Monthly Data)

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se	DW
Fuel v. Hours	606623	7.72	0.00	524.72	5.51	0.00	17.6%	17.0%	30.38	0	389873	1.56
Flt E. v. Hours	7015	1.24	0.21	2.648	0.39	0.70	0.1%	0.0%	0.15	0.699	27983	2.07
AFM v. Hours	567260	608	6.80	37.1	0.37	0.71	0.1%	0.0%	0.13	0.714	413934	1.82
DLR v. Hours	1402135	5.04	0.00	-232.8	-0.69	0.49	0.3%	0.0%	0.48	0.49	1379534	1.83
Totl v. Hours	2583034	7.14	0.00	331.4	0.76	0.45	0.4%	0.0%	0.57	0.451	1796071	1.88

Regression Formula for Fuel would only account for 17% of Relationship

CH-46E Regression Results (FY 95-98 - Monthly Data)

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se	DW
Fuel v. Hours	30278	1.89	0.06	174.1	8.98	0.00	46.2%	45.6%	80.62	0	57381	2.31
Flt E. v. Hours	15963	3.03	0.00	13.243	2.08	0.04	4.4%	3.4%	4.32	0.04	18862	1.91
AFM v. Hours	306356	4.58	0.00	530.98	6.56	0.00	31.4%	30.7%	43.04	0	239501	1.73
DLR v. Hours	409411	2.58	0.01	919.6	4.79	0.00	19.6%	18.8%	22.95	0	567993	1.7
Totl v. Hours	762009	4.22	0.00	1637.9	7.49	0.00	37.4%	36.7%	56.06	0	647351	1.58

Regression Formulas would only account for less than 50% of relationship

AV-8B Regression Results (FY 95-98 - Monthly Data)

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se	DW
Fuel v. Hours	191590	1.16	0.25	547.87	4.02	0.00	26.0%	24.4%	16.17	0	327034	1.96
Fuel(-1) v. Hrs	131778	0.81	0.42	604.5	4.47	0.00	30.8%	29.3%	20.02	0	319747	1.79
Flt E. v. Hours	4705	0.83	0.41	9.199	1.97	0.06	7.8%	5.7%	3.87	0.055	11230	0.66
AFM v. Hours	1122969	7.77	0.00	-20.9	-0.017	0.86	0.1%	0.0%	0.03	0.862	286139	1.55
AFM(-3) v. Hrs	1560903	10.63	0.00	-278.3	-2.27	0.03	10.7%	8.7%	5.17	0.028	288354	1.88
DLR v. Hours	2831993	4.56	0.00	27.1	0.05	0.96	0.0%	0.0%	0	0.958	1229115	1.59
DLR(-6) v. Hrs	3899819	6.1	0.00	-853.7	-1.56	0.13	5.8%	3.4%	2.45	0.126	1226734	
Totl v. Hours	415257	6.06	0.00	563.2	1	0.32	2.1%	0.0%	0.99	0.324	1356914	1.5

Regression Formulas would only account for 30% of Flight Hour relationships or less.

Marine Forces Pacific TACAIR Regression Results from AIRPAC OP-20 History Finals

MFPAC TACAIR Regression Results (FY 95-98) (Intercepts in 1000s of $)

X v. Y	a	T	P	b	T	P	R2	Adj R2	F	P	Se
Fuel v. Hours	-24582	-2.63	0.12	0.6414	10.22	0.01	98.1%	97.1%	104.51	0.009	1761.674
AFM v. Hours	136902	9.84	0.01	-0.0121	-1.28	0.33	45.0%	17.5%	1.63	0.328	2664.3

DLR v. Hours	244084	8.67	0.01	-0.1725	-0.89	0.46	28.7%	0.0%	0.8	0.463	5392.456
Totl v. Hours	356405	21.75	0.00	0.3474	3.1	0.09	82.8%	74.2%	9.66	0.089	3138.82

Regression Formula for Fuel = .64135(HOURS)

LIST OF REFERENCES

CHAPTER I

1. The Commandant's Planning Guidance Frag Order, section 3, j, (1), (b), July 1997, United States Marine Corps Home Page, http://www.usmc.mil/cmc.nsf/frag, accessed December 5, 1998.

2. Millet, Allan R., Semper Fidelis: The History of the United States Marine Corps, MacMillan Publishing Inc., NY, p. 465-466, c. 1980.

3. Simons, Robert, Levers of Control, Harvard Business School Press, Boston, MA, c. 1995.

CHAPTER II

4. Monthly Budget Review, Congressional Budget Office, October 1998, http://www.cbo.gov, p. 1, accessed October 6, 1998.

5. Federal Budget Analyst, October 1998, http://www.budgetanalyst.com, accessed October 15, 1998.

6. The Economic and Budget Outlook; Summary: Section 2 of 8, August 1998, p.1, http://www.cbo.gov, accessed September 1998.

7. The Economic and Budget Outlook, p. 11.

8. Monthly Budget Review, Congressional Budget Office, p. 1.

9. The FY 1999 Defense Budget and Future Years Defense Program, Chapter 21, February 1998, p. 1, http://www.dtic.mil., accessed October 1998.

10. The Economic and Budget Outlook, p. 9.

11. Director Naval Air Warfare, The Flying Hour Program, November 27, 1998, http://www.hq.navy.mil/airwarfare/programs/fhp/N88F.htm website., accessed December 5, 1998.

12. The FY 1999 Defense Budget and Future Years Defense Program, Appdx B, p. 2.

13. MN3222 Student View Graphs, Principles of Acquistion and Program Management II, pp. 3-14, 3-15, Naval Postgraduate School, Monterey, CA, 1998.

14. Edwards, Michael V., Flight Hour Costing at the Type Commander and Navy Staff Levels: An Analytical Assessment, Naval Postgraduate School, Monterey, CA, pp. 15-16, December 1992.

15. Practical Comptrollership, Naval Postgraduate School, Monterey, CA, pp. B-19 to B-23, April 1998.

16. Naval Center For Cost Analysis, Flying Hour Program Desktop Procedures Guide, p. 1-2, April 1998.

17. Interview between Major Brian Areman, MARFORLANT Aviation Budget Officer, Camp Lejeune, NC, and author 21 July 1998.

18. NCCA Desktop Procedures, p. 1-2.

19. NCCA Desktop Procedures, pp. 4-1 to 7-3.

20. NCCA Desktop Procedures, p. 9-3.

21. NCCA Desktop Procedures, p. 9-4.

22. NCCA Desktop Procedures, pp. 9-3 to 9-4.

23. NCCA Desktop Procedures, p. 1-3.

24. Edwards, p. 42.

25. Byrne, Vanessa J., Analysis of the Aircraft Flying Hour Program at the Pacific Missle Test Center, Naval Postgraduate School, Monterey, CA, December 1987.

26. Byrne, p. 41.

27. Arkley, Larry E., Modeling F/A-18 Flight Hour Program Cost Using Regression Analysis, Naval Postgraduate School, Monterey, CA, pp. 72-78, December 1994.

28. Memorandum Ser NCCA-32/079-98: NCCA CNO FLYING HOUR PROGRAM STUDY: RESULTS TO DATE, p. 1.

29. Memorandum NCCA 32/079-98, p. 3.

30. Memorandum NCCA 32/079-98, p. 2-3.

31. Edwards, Michael V., Flight Hour Costing at the Type Commander and Navy Staff Levels: An Analytical Assessment, Naval Postgraduate School, Monterey, CA, pp. 55-57, December 1992.

32. The Flying Hour Program's Budget and Execution, United States General Accounting Office, GAO/NSIAD-89-108, July 1989.

33. The Flying Hour Program's Budget and Execution, United States General Accounting Office, GAO/NSIAD-89-108, p. 3, July 1989.

34. Simons, p. 5.

35. Simons, p. 4.

36. Simons, p. 2.

37. Simons, p. 36.

38. Simons, p. 39.

39. Simons, p. 41.

40. Simons, p. 59.

41. Simons, p. 59.

42. Simons, p. 91.

43. Simons, p. 97.

CHAPTER III

44. Joint Publication 3-0, Doctrine for Joint Operations, Armed Forces Staff College, Norfolk, VA, p. GL-13, 1 February 1995.

45. Doctrine for Joint Operations, p. GL-11.

46. U.S. Marine Forces Atlantic homepage, November 1998, www.nfd.usmc.mil., accessed 1 November 1998.

47. NCCA Desktop Procedures, p. 5-2.

48. NCCA Desktop Procedures, pp. 5-2 to 5-3.

49. Notes from interview Major Areman interview.

50. Interview between CWO-5 Tim Pickett USMC, Mr. Jerry Cotton, 2nd MAW Comptroller's Office, Marine Corps Air Station, Cherry Point, NC, and author, 22 July 1998.

51. CWO-5 Pickett interview, and Keating, Peter J., and Paulk, David A., Examination of the Flying Hour Program (FHP) Budgeting Process and an Analysis of Commander Naval Air Forces Pacific (CNAP) FHP Underfunding, Naval Postgraduate School, Monterey, CA, December 1998.

52. CWO-5 Pickett interview.

53. Major Brian Areman interview.

54. Interview with "Draft Remarks for the Marine Corps Aviation Association Luncheon," by General Charles C. Krulak, September 23, 1995, p. 1, United States Marine Corps Homepage, www/usmc.mil/cmc, accessed October 1998.

55. Interview between LCDR Mark Timme (USN), at Budget Office of Commander Naval Air Forces, Atlantic, Norfolk, VA, and author, 23 July 1998.

56. LCDR Mark Timme interview, and Telephone Conversation between Major Alex Ihde, USMC, Ground Budget Officer, U.S. Marine Forces Atlantic, October 1998.

57. "Changes Needed to Support the Navy and Marine Corps of the 21st Century," Report from the Naval Aviation Maintenance and Supply Readiness Working Group, San Diego, CA, 23 April 1998.

58. Notes from interview between Colonel Dave Landolfi USMC, Comptroller, 2nd Marine Aircraft Wing, and author, 22 July 1998.

59. "CNO Flying Hour Program: Naval Center For Cost Analysis Model," presentation by LCDR Dave Tiller and Mr. Kyle Ratliff, Annual Flying Hour Program Conference, Norfolk, VA, February 9-12, 1998.

60. Arkley, pp. 61-62.

61. "Navy Working Capital Funds" presentation by Rear Admiral Keith W. Lippert USN, Vice Commander, Naval Supply Systems Command, Naval Postgraduate School, Monterey, CA, 28 July 1998.

62. Colonel Dave Landolfi interview.

63. "Under-funding of the MARFORLANT/2d MAW Flight Hour Program," Information Paper by Colonel Dave Landolfi, Comptroller, 2nd Marine Aircraft Wing, Cherry Point, NC, 9 July 1998.

64. "The Marine Aviation Campaign Plan," in <u>The Marine Corps Gazette</u> Quantico, VA, p. 1, March 1998.

65. "The Marine Aviation Campaign Plan," p. 1.

CHAPTER IV

66. Arkley, p. 33.

67. Arkley, p. 34.

68. Arkley, p. 36.

69. Liao, Shu S., Regression Techniques for Managerial Planning and Control, Naval Postgraduate School, Monterey, CA, p. 2-3.

70. Liao, p. 2-2.

71. Liao, p. 2-6.

72. Liao. p. 2-7.

73. Liao. p. 2-10.

74. Liao, p. 2-12.

75. Liao, p. 2-12.

76. Levine, David M., Berenson, Mark L., Stephan, David, Statistics for Mangers Using Microsoft Excel, Prentice-Hall, Inc., Upper Saddle River, NJ, p. 562, c. 1997.

77. Levine, p. 562.

78. Liao, p. 4-3.

79. Liao, p. 4-9.

80. Liao, p. 4-6.

81. Liao, p. 4-4.

82. Levine, p. 652.

83. Liao, p. 4-11.

84. Electronic mail message from Colonel Dave Landofi, Comptroller, 2nd Marine Aircraft Wing, Cherry Point, NC, November 14, 1998.

85. NAVCOMPT 7111, Budget Guidance 98-2, Encl. 1-5, http:\\navweb.secnav navy.mil/guidance/notes/notes_u.html, accessed September 1998.

86. NAVCOMPT 7111.

87. Keating and Paulk, notes from thesis research.

CHAPTER V

88. Colonel Dave Landofi, CWO-5 Pickett interviews.

89. Telephone conversation with Mr. Jerry Cotton, Comptroller's Office, 2nd Marine Aircraft Wing, Cherry Point NC, September 23, 1998.

90. E-mail message from Mr. Jerry Cotton, November 14, 1998.

91. Mr. Jerry Cotton interview, CWO-5 Pickett interview.

92. Simons, p. 79.

CHAPTER VI

93. "Under-funding of the MARFORLANT/2d MAW Flight Hour Program," Information Paper by Colonel Dave Landolfi.

94. "Under-funding of the MARFORLANT/2d MAW Flight Hour Program," Information Paper by Colonel Dave Landolfi.

95. Arkley, p. 63.

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